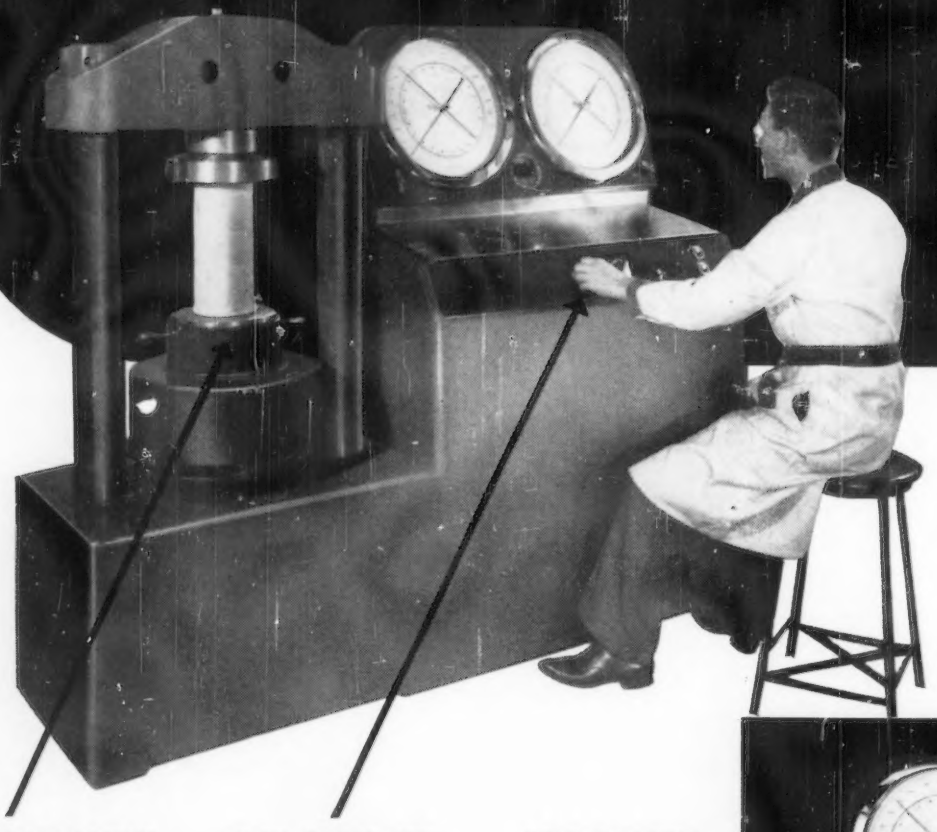
Bulletin

Precision RIEHLE HYDRAULIC COMPRESSION TESTING MACHINE

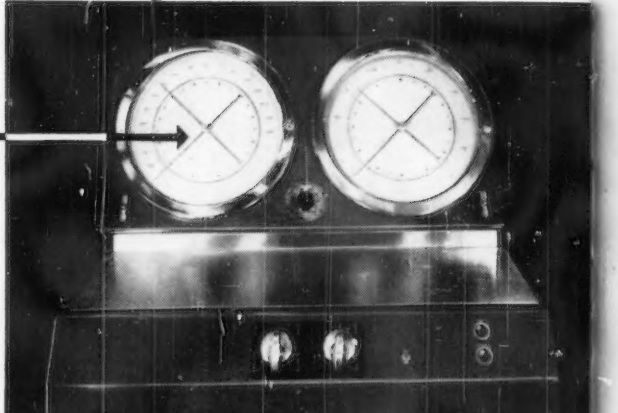


NOW AVAILABLE in 200,000 300,000 400,000 lbs. CAPACITIES

FAST ADJUSTMENT
Anvil speedily positioned without pressure.

EASY OPERATION
Single control for loading, unloading, holding.

EASY READING
Slanting dial simplifies, speeds up testing.



Single handwheel at left controls all testing operations: loading, unloading, holding and return. Handwheel at right positions anvil without pressure for faster adjusting prior to test. Stainless steel writing table is standard equipment.

Riehle Precision Hydraulic Compression Testing Machines offer new convenience in testing concrete, cinder block, building block, masonry units and other specimens. These Riehle testing machines are furnished in two standard ranges: 0-60,000 lbs., and 0-300,000 lbs. Testing machines of 200,000 and 300,000 lbs. capacities have stationary type head . . . models of 400,000 lbs. capacity have motor-driven head. Special scale ranges available at extra cost, if desired. Constant rate of load pacer (shown between dials in photos) also available at slight additional cost.

Write for Illustrated Literature

RIEHLE *TESTING MACHINES*

Division of

AMERICAN MACHINE AND METALS, INC.

East Moline, Illinois

District Offices: San Francisco, Chicago, Cleveland, Pittsburgh, Philadelphia, New York, Washington, D. C.

In Canada: American Machine and Metals (Canada) Ltd., 1144 Weston Road, Toronto 9, Ontario

Foreign Sales Office: Woolworth Building, New York 7, N. Y.

OTHER RIEHLE Testing Machines

- Mechanical Universal Testing Machines with Thy-mo-trol Electric Control
- Impact Testers
- Torsion Testers
- Hardness Testers
- Plywood Testers
- Cement Briquette Testers
- Rope and Cable Testers
- Precision Instruments

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

ASTM Bulletin, January, 1949. Published six times a year, January, March, May, August, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the headquarters of the Society, 1916 Race St., Philadelphia 3, Pa. Subscription $2.00 a year in United States and possessions, $2.25 in Canada, $2.50 in foreign countries. Single Copies—50 cents. Number 156. Entered as second class matter April 8, 1940, at the post office at Easton, Pa., under the act of March 3, 1879.

ASTM BULLETIN

Published by
AMERICAN SOCIETY for TESTING MATERIALS

This Issue Contains

NEWS ABOUT THE SOCIETY AND ITS COMMITTEES:

MISCELLANEOUS NEWS NOTES:

ASTM Bulletin is indexed regularly by Engineering Index, Inc.

JANUARY—1949
No. 156

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315

R. E. Hess, Editor
R. J. Painter, Associate Editor

CABLE ADDRESS—TESTING

Number 156 January, 1949

1948 a Notable Year for Advancing A.S.T.M. Work in Materials

Several New Technical Committees Organized, Important New Publications Issued, Intensive Activity Generally. Highlights Noted

THE year 1948 was a notable one with respect to progress made in the Society's work generally. A large number of new specifications and tests for materials were developed and much new research work on the properties and testing of materials was inaugurated, and many of the existing research projects were given considerable impetus during the year. 1948 was marked for the number of new fields of work which the Society will undertake. Several new technical committees were organized and a number of subcommittees were set up in some of the existing groups to expand the scope of the standardization and research work already under way in specific materials fields.

Difficulty of a Comprehensive Review:

Years ago it was the custom to include in the January ASTM BULLETIN a comprehensive review of A.S.T.M. activities for the past year. As the work expanded, problems of covering all of the ramifications adequately in a review article increased, and with the added pressure on the staff due to prewar and war activities the review article was dropped (not without some sighs of relief, to be sure, from the editors).

Nevertheless the review article did have some desirable attributes—in particular, it drew attention to the large number and variety of projects which A.S.T.M. had under way.

It is felt that some very condensed notes on major developments during 1948 may be of interest, and some of our inhibitions and fears about a general review article will not arise because the purpose of what follows is *not* to review *but to highlight.*

With upwards of ten thousand members and committee members and a great diversity of interest, no one could pick out those phases of our work which are considered "most" important for all. A new steel casting specification or the addition of a new grade of steel to an existing specification may be far more important to one company or individual or industry than all the other A.S.T.M. work. A new bit of knowledge on the effect of chemically reactive materials on concrete durability might be of paramount importance to the builder of a dam or some other structure, and so on *ad infinitum.*

The various items noted below are those which in the opinion of the editors and the technical men at headquarters seem generally quite significant in the specific fields involved. If anyone wishes further details on any of the material, more data are available in the annual reports of the technical committees, in the 1948 ASTM BULLETINS, and such sources.

Welding Filler Metal Specifications:

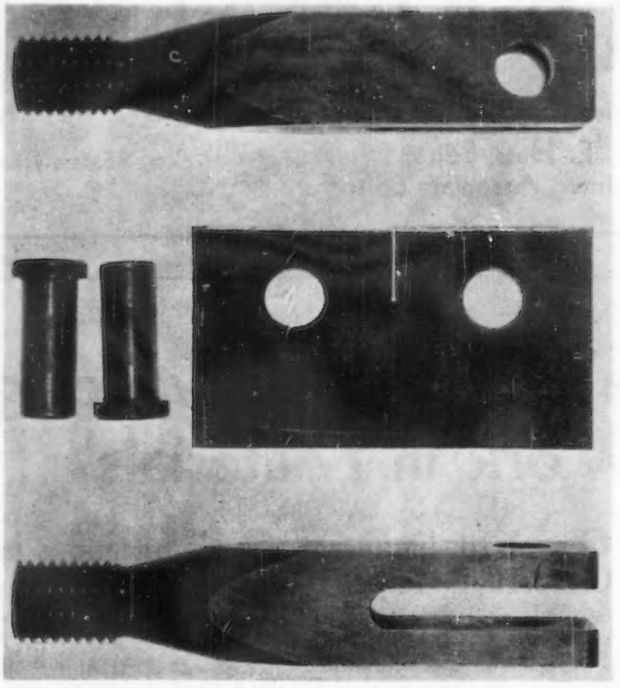
The work of the Joint A.S.T.M.-A.W.S. Committee on Filler Metals during 1948, resulting in four specifications for arc welding electrodes, places it in the spotlight of notable accomplishments. Two of the tentatives, A 233 and A 316, covering mild steel and low alloy electrodes, really represent a division and expansion of the former standard A 233. The stainless specification A 298, embodying a number of changes, has been expanded to include 40 classifications of material. New specifications for copper and copper alloy electrodes (B 225) are the first in this field. Arc welding of various types of copper and copper alloys has increased considerably.

Fatigue Manual—In Progress:

While not yet finished, considerable progress was made by Committee E-9 on Fatigue in completing its Manual of Fatigue Testing. The chapter on Nomenclature was published in the August BULLETIN, and the other sections are progressing. This should be a most significant publication.

Symposium on Deformation of Metals as Related to Forming and Service:

An accomplishment of the Administrative Committee on Simulated Service Testing was the Symposium in June, on Deformation of Metals as Related to Forming and Service, with five interesting technical papers. Topics covered include tests of ductility in ship structure, notch-sensitivity in ship-plate correlation of laboratory scale tests with large-scale plate tests, measurement of ductility in sheet metals, hydraulic bulge testing of sheet metals, and notch bar tension tests on annealed carbon steel specimens of various sizes and contours. The new testing procedures that are covered are intended to simulate closely actual service conditions, and as indicated in the symposium, they serve as a proving ground between theory and practice of applying materials for structural uses.



Loading Shackles and Pins and the Machined Navy Tear Test Specimen Used in Determining Notch Sensitivity of Ship Plate—Part of the Symposium on Deformation of Metals as Related to Service.

Corrosion and Related Matters:

(*a*) *Iron and Steel.*—The annual report of Committee A-5 on Corrosion of Iron and Steel is significant because it includes latest tables covering the inspection of black and galvanized sheets with the record of failures and data on the life of the sheets. Also given are the voluminous data from the 1947 inspections of the field tests of wire and wire products, and extensive tables summarize the data on the field tests of bare and coated hardware, structural shapes, etc. A great deal of work, both in the field and in the office-tabulating and correlating the results, is what makes possible the condensed tables and descriptions of the tests as given in the published report.

(*b*) *Humidity and Weather.*—The report of Committee B-3 on Corrosion of Non-ferrous Metals and Alloys is marked by the interesting data resulting from five years' exposure of stainless steels coupled with other metals, and a significant paper relating to salt fog testing.

Also noted is the work of the Subcommittee on Humidity Tests which will be a cooperative effort because of the interest of several other technical committees. The group concerned with the status of the weather at the various test sites is undertaking studies of the relative corrosivity at the sites to obtain data, and will obtain data by exposing a number of specimens.

Metallic Materials for Radio Tubes:

There has been notable progress in the intensive research work being carried on in Committee B-4 relating to the emissivity of cathode metal, where a special section functions under the subcommittee for metallic materials for radio tubes. Not only is much research under way, which already has been productive of valuable results, as noted elsewhere in this BULLETIN, but certain test methods and procedures are being prepared, some of them having been well advanced during 1948.

Classification of Copper:

The significant tentative Classification of Copper (B 224) issued in March was a result of joint activity of Committee B-1 on Wires for Electrical Conductors, B-2 on Non-Ferrous Metals, and B-5 on Copper and Copper Alloys, working through a joint committee which is under the jurisdiction of the three main technical groups. This classification covers the types of copper currently available in refinery shapes and wrought products in commercial quantities. Eighteen types of copper are covered with data on the forms in which available, these coppers being classified broadly into four groups: electrolytic cathode, tough pitch coppers, oxygen-free coppers, and deoxidized coppers. The terms used in the classification are defined. This work is significant because there have been discussions in the various individual committees for a number of years with no results. This Classification B 224 is really a companion document to the Classification of Cast Copper-Base Alloys B 119.

Research on Effect of Temperature on the Properties of Metals:

Increasing industrial uses of some of the highly alloyed materials used for war applications such as gas turbines, etc., and the eventual need for adequate test methods for the properties of these alloys, lead to the expansion of the A.S.T.M.-A.S.M.E. Joint Committee on Effect of Temperature on the Properties of Metals. This group now has a subcommittee structure which will divide the work of its enlarged personnel in older fields, for example steam power applications, but also includes gas turbine materials and others.

Wires for Electrical Conductors:

Whatever award might be given for concentrated work on specifications certainly in 1948 would have been given to Committee B-1 on Wires for Electrical Conductors. Not only did this group develop eight new specifications for certain types of conductors made from combinations of materials but it set up important revision in existing standards. The specifications will meet a demand from both the users and manufacturers of conductors of aluminum and combinations of steel with aluminum and with copper. While the use of such conductors is not new this is the first time that nationally recognized specifications have been issued for them. Somewhat the same analysis holds for all-copper conductors stranded in annular form which are covered in new tentatives.

Microhardness Testing:

Despite the use of microhardness testing for a good many years, no work along standardization lines has been attempted, and the growing use of the methods led to a new Subcommittee V in Committee E-4 on Metallography. This group has had several intensive discussion periods and it is evident that before long some tangible results and proposals will come from these discussions.

Organic Reagents for Metal Analysis:

The purpose of the all-day symposium on Organic Reagents for Metal Analysis arranged by Com-

mittee E-3 in March in Washington was to aid in keeping its membership informed on subjects of special interest, and at the same time to provide an opportunity so that the latest information on the problems could be made available. The five technical papers cover organic reagents for gravimetric analysis, in metal analysis, in colorimetric analysis, as used for volumetric analysis, also as oxidation-reduction indicators. They were abstracted in the March, 1948, ASTM BULLETIN. This is one of a series of such symposia sponsored by Division D on General Analytical Methods. At this same meeting there was an extensive exhibit of books on organic reagents and related subjects, these publications also being listed in the BULLETIN.

Symposium on Color Metallography:

The Symposium on Metallography in Color held during the 1948 annual meeting in Detroit was the first open discussion of this subject in A.S.T.M. Committee E-4 on Metallography has considered various aspects of the subject and there was at least one technical paper, illustrated in color, published in the BULLETIN some years back. The need for information on proper techniques to record colors seen visually led to the symposium which will be published early in 1949. A number of technologists who have become proficient in this field discussed such matters as precautions necessary in specimen preparation, color of the illumination, experiences in photographing nonmetallic inclusions, the use of polarized light, etc. This book when published will afford an authoritative treatise and cover many questions in the field. It will undoubtedly stimulate the use of color in metallographic work.

X-ray Diffraction:

A specialized field of work in which the A.S.T.M. has joined with other groups involves chemical analysis by X-ray diffraction. The joint committee on this subject, sponsored by the A.S.T.M., the American Society of X-ray and Electron Diffraction, and the British Institute of Physics, expanded its membership considerably during the year, and also acted to intensify its activities in the preparation of supplements to its existing set of 4500 cards identifying crystalline materials. This card index file has come into universal use. A supplementary set of almost 1500 cards, rearranged and simplified, should be issued soon.

Nondestructive Testing:

The expansion of the scope of former Committee E-7 on Radiographic Testing to include nondestructive testing in general is an important 1948 development. This committee has an enviable record of accomplishment in radiographic testing and is expected to contribute greatly to its broader field of application, which includes the use of magnetic powders, ultrasonic tests and others which are used in detecting discontinuities or structural irregularities in materials. Committee E-7 is expanding its personnel considerably to bring in the various interests concerned. It will concentrate on general test procedures but will not infringe on the provinces of the various committees establishing product specifications.

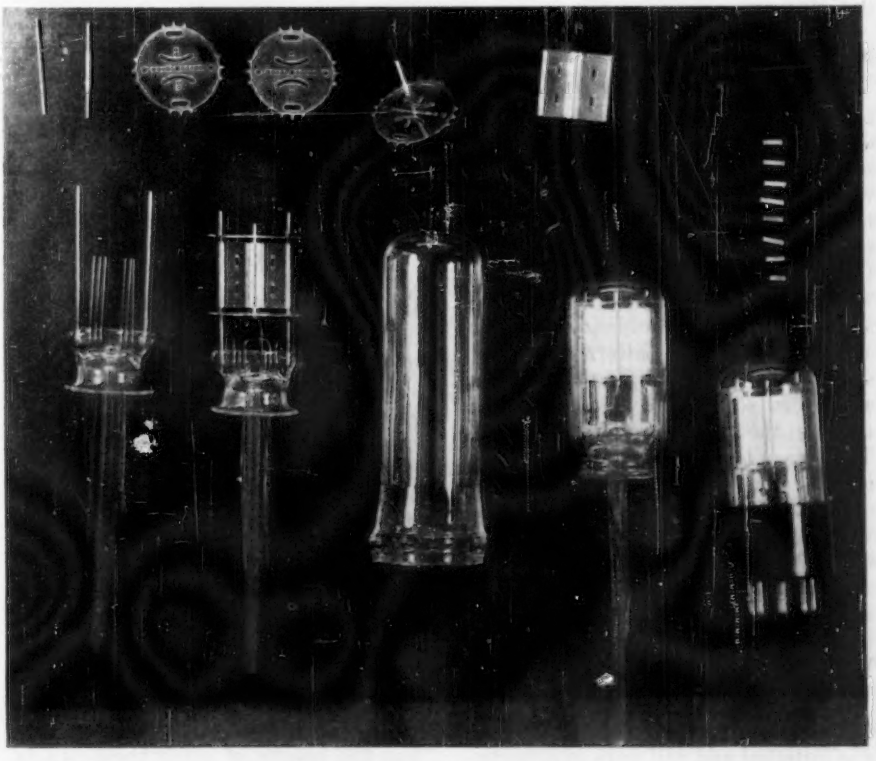
Discussion on Ultrasonic Testing.—Committee E-7, cognizant of the interest in ultrasonic testing, sponsored at the Detroit annual meeting a round-table discussion of the subject with prepared papers and comments from the floor. The large number in attendance is indicative of the importance of this relatively new method of evaluating the soundness of various materials.

Samples:

Increasing attention unquestionably will be given to methods of sampling as the use of quality control methods increases. The number of samples and how obtained are important in the test procedures standardized in A.S.T.M. The significance of this subject was stressed in the Symposium on the Usefulness and Limitation of Samples held at the 1948 meeting under the auspices of Committee E-11 on Quality Control of Materials. The useful booklet with the three technical papers has just been published and, as indicated in the December BULLETIN, which presents a review of the pamphlet, it should be of interest to almost everyone concerned with the field of materials. Topics covered in the papers include sampling and its uncertainties, variation in materials, testing and sample sizes, and the amount of inspection as a function of control of quality.

Symposium on Mineral Aggregates:

This 300-page symposium is outstanding among the numerous special publications issued during the year. It affords a comprehensive coverage of the distribution, characteristics, and



The Standard Diode—An Important Element In the Work on Radio Tubes

The completed diode is shown in the lower right with various parts shown above and the assembly operations to the left.

uses of the various types of mineral aggregates, and covers in some detail the significant developments since the last symposium under this same title was held, just twenty years ago. Many of the country's leading authorities participated as authors or discussers in the symposium, or in making the plans and arranging for the symposium and its publication. This is a most significant accomplishment—of interest and service to all concerned with aggregates.

Reactive Materials in Concrete:

The subject of chemically reactive materials in concrete and their effect upon its durability is not new either to other groups concerned or to A.S.T.M., for it has been under study for many years. However, the intensive interest and attention given to solving some of the problems and the resulting information, together with the A.S.T.M. Symposium on the subject, mark the subject as a 1948 highspot. The published symposium is extremely important—giving a comparison of the various methods which have been in use to identify reactive materials. Various laboratory methods were correlated with field work, and from this symposium and the discussions in the committees it is hoped standardized methods will result. These would be of utmost importance.

Structural Sandwich Constructions:

No one in the materials field need be told about the growing significance of composites—putting different materials together to form a homogeneous whole, and recognition of the importance of so-called sandwich constructions led to the organization of a new Committee C-19 on Structural Sandwich Constructions. These constructions, usually laminar, comprise a combination of alternating dissimilar simple or composite materials assembled so that advantage can be taken of the special properties of each. The face of these constructions usually is some dense material such as metal or plastic, in between which is a lightweight porous or other material. The new A.S.T.M. committee already has several subcommittees actively at work.

Whitewares:

Another new technical committee, Committee C-21, covering whitewares, was initiated and will work in cooperation with a division of the American Ceramic Society. It includes in its scope such products as sanitary ware, electrical porcelain, laboratory porcelain, stoneware, dinnerware, and ceramic tile.

In Progress:

(*a*) *Acoustical Materials.*—The importance of adequate methods of evaluating another class of materials is being recognized through the organization of a new committee, C-20 to deal with acoustical materials, which, for the purpose of the committee, are those used as airborne sound-absorbing materials.

(*b*) *Porcelain Enamel.*—Another new technical committee just authorized by the Board will cover porcelain enamel. This group will be organized during the next few months and will deal with a product closely akin to the whitewares committee.

Engine Test Methods for Rating Fuels:

A most important publication was issued early in 1948 providing in full detail the various methods and related information covering the use of engine tests for rating fuels. This 340-page so-called "Knock Test Manual" was the result of very intensive work in Committee D-2's Division of Combustion Characteristics. In addition to the methods proper, pertinent information covers the apparatus, reference materials, operation and maintenance, installation and building requirements, with numerous tables and charts and other illustrations.

An important appendix bringing up to date this "Knock Test Manual" and noting certain corrections is being published in January, 1949.

Specifications for Diesel Fuel Oils:

The completion of new tentative specifications for Diesel fuel oils, D 975, was an important achievement in Committee D-2's Technical Committee F. Three grades of oils suitable for various types of Diesel engines are covered, and the form of the specification is similar to the widely used and important requirements for burner fuel oils, D 396, which had significant changes effected during 1948.

Symposium on Turbine Oils:

While this symposium comprising four short papers was informal, the discussions of service experience with these inhibited oils do provide a better understanding of turbine construction and the results of using these oils in central stations and in industrial turbines. The papers were published in the May, 1948, BULLETIN.

Symposium on Functional Tests for Ball-bearing Greases:

Work is under way in Technical Committee G of A.S.T.M. Committee D-2 to develop performance tests of greases and to provide information on the variety of tests which have been used. This five-paper symposium with considerable discussion was held during the annual meeting and has just been published. The authors were from a variety of interests including the producers and consumers, the concluding paper covering factors affecting simulated service tests of greases.

In connection with work on greases, several methods of evaluating their properties have been issued.

Calorific Values of Gaseous Fuels by the Water-Flow Calorimeter:

In 1946 there was issued as a result of very extensive work in Committee D-3 on Gaseous Fuels a most important method of test for the calorific value of gaseous fuels (D 900). In 1948, following some revisions, this method was adopted as standard. It is one of the most voluminous standards published by the Society and covers the application of water-flow calorimeters in determining the total and net calorific value of fuel gases as purchased and sold, but is

Parallel Jointing in Granite Simulating Stratification in Sedimentary Rocks, Kortes Damsite, Wyo.—From the Symposium on Mineral Aggregates.

restricted to fuels having total calorific values of 300 to 3000 Btu. per standard cu. ft.

Sampling Coal in Connection with Smoke Ordinances:

This new method (D 980) covering the sampling of coal for volatile matter determinations in connection with smoke ordinances is particularly significant because of the intensified interest in atmospheric conditions in many of our urban communities. In probably no other year has there been so much interest, popular as well as technical, in smoke and so-called "smog" conditions. The method is based on sampling experiments to determine the minimum gross sample required to give an accuracy for volatile matter of ±1 per cent on the moisture- and ash-free basis. It is applicable to the sampling of relatively small quantities of coal as delivered to apartment buildings, hotels, laundries, domestic consumers, etc., where it is impracticable to collect large gross samples. The stipulation that volatile matter is to be reported on the moisture- and ash-free basis makes it practical to collect smaller gross samples than would be required for the same degree of accuracy if the analysis were reported on the customary as-received basis.

This method was developed in Subcommittee XIII of Committee D-5. This group also recommended improvements in the various riffle samplers used in some of the sampling methods issued previously.

Testing Pressure-Sensitive Tapes:

While the new methods of testing pressure-sensitive tapes used in electrical insulation are quite significant, covering as they do "scotch" tape and such materials, and the methods carry the rather significant serial designation "D 1000," this work is only one of a number of activities going on in Committee D-9. This group has many cooperative test programs under way, and during the year there were issued various new tentatives, one covering high-voltage, low-current, arc resistance of solid materials, and another as a result of very extensive work in the field of insulating oils covering the detection of free sulfur.

Stress-Strain Testing of Textiles:

Three significant technical papers dealing with the determination of the properties of textile fibers and materials were presented at a meeting of Committee D-13 in March, and subsequently published in the Special Compilation of Standards issued in October of last year, covering the importance of the time factor in studying textile properties, a stress-strain diagram as a tool in textile research, and the stress-strain measurements as applied to determining fiber properties. They relate to a subject in which the late Dr. Harold DeWitt Smith, to whom the paper session was dedicated, was interested, namely, an engineering approach to the production of textile structures designed for specific end-use applications.

Inter-Laboratory Testing:

Because inter-laboratory tests are widely used in the Textile Committee D-13, it was logical for the committee to prepare this recommended practice for planning the inter-laboratory testing of textile materials, designated D 990. While the recommendations are general in nature because of the wide diversity of tests studied, nevertheless they are very specific in emphasizing points where great care must be taken. Some of the questions covered include—how many tests should be made by one operator on one sample, how many samples should be used per operator, how many materials should be included in the master plan, etc. An appendix gives examples of the use of the recommended practice. This document may be of interest to many of the other technical committees of the Society, and it is certainly significant as an important 1948 development.

Estron:

There has been much discussion of definitions of the term "rayon," and as a result of considerable thought in Committee D-13 the standard definition was changed to provide definite recognition of cellulose ester fibers having properties sufficiently different from the regenerated cellulose fibers such that a new generic term would be justified, and this is "estron," the definition for "estron" reading as follows:

> "a generic term for man-made fibers, monofilaments and continuous filament yarns composed of one or more esters of cellulose with or without lesser amounts of nonfiber-forming materials. NOTE.—Estron as commercially manufactured is produced at present by one process, namely, Cellulose Acetate Estron (Acetate Estron)."

Water-borne Industrial Wastes:

With present-day trends of having each industry keep its own house in order and dispose of its own refuse, and many laws and regulations going on the statute books, it was felt that Committee D-19 on Industrial Water could make a definite contribution, and a new Subcommittee on Water-borne Industrial Wastes has been organized. The personnel already numbers upwards of 70, which is a direct indication of the interest in the subject. This committee will cover the preparation of standard methods of sampling, the preservation and analysis of samples, and methods of reporting results of tests.

Particle Size Distribution:

The new recommended practice for analysis by microscopic methods for particle size distribution is essentially a revision of the methods E 20. The recommendations are based on rather extensive research work, and the committee feels that while the document is not the final answer in all respects, it is a distinct improvement over the earlier methods. Committee E-1, through its special section, is satisfied concerning the errors of measurement involved, but certain other effects noted in the cooperative research are to be studied later. The requirements are broad, because the range of products capable of measurement with the microscope are extensive.

Standard Laboratory Atmosphere:

While a change in the temperature of the atmosphere from 77 F. to 73.4 F., equivalent to 25 and 23 C., respectively, might not seem important, actually the change in the Definitions with Procedures Relating to Conditioning and Weathering (E 41) is important because it will bring the requirement in line with the latest Federal proposals. The new provisions indicate that the standard laboratory atmosphere has a relative humidity of 50 ± 2 per cent, at a temperature of 73.4 ± 2 F.

Appearance Properties:

The new Technical Committee E-12 on Appearance is the result of the need for a central coordinating agency to which other technical committees can turn for advice on this broad subject. The committee was organized in the early fall and has as its general scope the improvement and development of methods for describing and evaluating the appearance properties such as color, gloss, opacity, and texture of engineering materials.

Symposium on Aging of Rubbers to Feature Spring Meeting

Technical Session and Dinner, Chicago, March 2; Numerous Meetings During Committee Week

THE technical feature of the 1949 A.S.T.M. Spring Meeting to be held in Chicago at the Edgewater Beach Hotel on Wednesday, March 2, is to be a Symposium on the Aging of Rubbers. This symposium is sponsored by Technical Committee D-11 on Rubber and Rubber-Like Materials, and six technical papers by leading authorities in their fields will form the basis of the symposium. Numerous other men will be asked to present discussion and participate in the symposium.

Another feature of the Spring Meeting is to be a dinner with ensuing entertainment under the auspices of the Chicago District, the Council of which is arranging to have Mr. John Nash Ott, Jr., give his colored motion picture and lecture entitled "Flowers in Action," a most interesting and unusual demonstration, and the New Trier Township High School Glee Club will provide a program. Further notes on these features appear below.

Committee Week:

Throughout the week beginning February 28 through Friday, March 4, there will be a large number of meetings of A.S.T.M. technical committees. It is expected that approximately 200 meetings will be held starting Monday morning and continuing throughout the week. A.S.T.M. Committee Week has been held in the spring each year since the 1920's. A feature of it is the saving of time and travel expenses since so many of the men who serve on different technical committees can, in a concentrated two- or three-day period attend the meetings of their different groups which are scheduled. An effort is made to schedule committees so that there will be a minimum of overlapping memberships.

Each member of the Society will receive well before the meetings a detailed schedule of the individual meetings and a final schedule with room assignments will be available at the Edgewater Beach Hotel. A list of the main technical committees which thus far have signified their intention of meeting, follows.

LIST OF MAIN TECHNICAL COMMITTEES TO MEET DURING WEEK

MONDAY, FEBRUARY 28, TO FRIDAY, MARCH 4, INCLUSIVE

*A-3 on Cast Iron
A-5 on Corrosion of Iron and Steel
A-9 on Ferro-Alloys
A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys
B-3 on Corrosion of Non-Ferrous Metals and Alloys
B-6 on Die-Cast Metals and Alloys
*B-7 on Light Metals and Alloys, Cast and Wrought
B-8 on Electrodeposited, Metallic Coatings
C-1 on Cement
C-2 on Magnesium Oxychloride Cements
C-8 on Refractories
C-9 on Concrete and Concrete Aggregates
C-15 on Manufactured Masonry Units
C-16 on Thermal Insulating Materials
C-17 on Asbestos-Cement Products
C-19 on Structural Sandwich Constructions
D-1 on Paint, Varnish, Lacquer, and Related Products
D-4 on Road and Paving Materials
D-5 on Coal and Coke
D-8 on Bituminous Waterproofing and Roofing Materials
D-11 on Rubber and Rubber-Like Materials
D-19 on Industrial Water
E-1 on Methods of Testing
E-4 on Metallography
E-6 on Methods of Testing Building Constructions
E-9 on Fatigue
E-12 on Appearance

*Subcommittees only

Symposium on Aging of Rubbers

Chicago, March 2

THE problem of aging and deterioration of rubbers because of the actions of various elements is one of the most serious and perplexing facing the producers and users of rubber products. While the essential use of rubber during the war period at quite high and extremely low temperatures focused attention on aging and deterioration, the problems are not new by any means. It will be the purpose of this symposium which is sponsored by Committee D-11 on Rubber and Rubber-Like Materials to bring together in convenient and condensed form the latest information on various aspects of aging. A special committee headed by G. C. Maassen, R. T. Vanderbilt Co., Inc., as chairman, has enlisted the help of leading authorities, and six technical papers as indicated below will form the basis of the symposium. Other leaders will be asked to discuss the various subjects.

Some idea of the elements and agencies which may affect rubber is given by the titles of the papers, but include oxygen, ozone, and light, temperature, chemicals, fungi, etc.

The rubber technologist has done a magnificent job in making available wide varieties of rubbers for different applications. He is "hemmed in" on the one hand with necessity of selecting types and cures, and such conditions, so that there will be proper vulcanization, and on the other hand with the effects of his choices on the ensuing physical properties including resistance to aging and the elements which cause it.

Committee D-11 is having an extensive series of meetings in Chicago and it is expected there will be a heavy attendance at this symposium.

Mode of Attack of Oxygen on Rubbers—A. M. Neal, Assistant Director, Rubber Laboratory, E. I. du Pont de Nemours and Co., Wilmington, Del.

Oxygen Absorption Methods and Their Utility and Limitations in the Study of Aging—J. R. Shelton, Case School of Applied Science, Cleveland, Ohio.

Chemical Changes in Elastomers and Antioxidants during Aging—John O. Cole, Research Laboratory, Goodyear Tire and Rubber Co., Akron, Ohio.

The Physical Aspects of the Aging of Rubbers—M. C. Throdahl, Rubber Laboratory, Monsanto Chemical Co. Nitro, W. Va.

Aging Effect of Ozone and Light on Rubbers—J. T. Blake, Simplex Wire and Cable Co., Cambridge, Mass.

Effect of Temperature on the Aging of Rubbers—M. J. Schoch, Jr., Hewitt-Robins, Inc., Buffalo, N. Y., and A. E. Juve, Research Center, B. F. Goodrich Co., Brecksville, Ohio.

None of the papers will be issued in preprinted form in advance of the meeting, although some copies may be available for the use of discussers. It is expected the Society will publish the papers in the form of a special book during the year. This would of course include discussion as well as the actual papers.

The Committee D-11 officers, Simon Collier, Chairman, and Arthur W. Carpenter, Secretary, have taken a most active part in plans for the symposium in cooperating with the symposium committee.

In the work of Committee D-11 itself, cognizance has been taken of the problems of aging and a number of tests to determine the effect of deteriorating elements have been issued, for example, one covering an air pressure heat test (D 454), accelerated aging of vulcanized rubber by oxygen-pressure method (D 572), the oven accelerated aging procedure (D 573), and also test tube method of heat aging (D 865). Various A.S.T.M. standard specifications for different products incorporate the requirements on aging and the use of tests. As an example, the automotive air and vacuum brake hose specification D 622 has aging test requirements.

A cordial invitation is extended to all members and committee members and anyone interested to attend the symposium.

Chicago—"The Top of the Convention World"

● THE 1949 National A.S.T.M. Spring Meeting to be held March 2 at the Edgewater Beach Hotel and Committee Week, Feb. 28–March 4, will follow the meeting trend of many national organizations as guest of the "Convention Host to the Nation."

● During World War II when governmental restrictions eliminated or reduced all sorts of meetings because of the unusual demands on transportation and hotel facilities, Chicago pointed out the advantages of its central location and the city remained a center of essential meeting activity. Today this trend continues, according to the Chicago Convention Bureau, which notes that every 44 seconds a railroad train arrives in or departs from Chicago. Through its busy airport flows one of the heaviest volumes of traffic on the aviation map. As the hub of a nation's great highway system, there speed through it more than 30 bus lines. In the summer the Great Lakes shipping lines make Chicago a regular port of call. There are 1385 hotels with an estimated 135,400 rooms available to guests.

● Chicago, itself, is a sprawling city covering 25 miles on the west shore of Lake Michigan. The 200 square mile area offers resort facilities along with its large industrial and business center.

● Visitors to Chicago seeking complete and rapid orientation stand at the intersection of State and Madison Streets. State Street runs north and south; therefore, it presents the East and West sides of Chicago. Madison Street runs east and west, thus dividing the city into its North and South Sides.

● The city's street numbering system emanates from these two streets, too. Usually running one hundred numbers to each block, the east, west, north or south designation stems from its location on one side of State—or Madison—Street.

● From the intersection of State and Madison, you look north to the Chicago River, east to Lake Michigan, south down State Street and west to Sioux City and the wide open spaces.

● State Street is one of the big reasons why more and more delegates are arriving in Chicago accompanied by the "Missus." She wants to shop in the shopping district, the ten-block stretch along State Street, which will do about $450,000,000 in business in a normal year. The number of its customers is running about 500,000 daily. According to the shipping managers of the big stores a good proportion of the activity is to be found in shipments to homes in various parts of the country.

● Number one attraction for visitors throughout the years is the Loop. Roughly a half mile square, this heart of the business section of Chicago has long outgrown itself, extending in all directions from the loop made by the elevated train.

Entrance to the Edgewater Beach Hotel

Interesting Dinner Program Planned

AS THE host group, the Chicago District, through its Council, wished to arrange for some function during Committee Week, preferably as part of the Spring Meeting and with a technical symposium scheduled it was felt members would appreciate an entertainment program rather than additional talks or addresses. Accordingly two features which promise to be extremely interesting and entertaining are on the schedule following dinner.

Preceding the dinner there will be a cocktail hour when those at the Spring Meeting and attending committee meetings will be the guests of the Chicago District. Tickets for the dinner are on a subscription basis and the district council is most anxious that as many as possible make their reservations early. The charge is $5.50. Reservations can be made directly with A.S.T.M. Headquarters. Remittance should accompany the reservations.

Acting for the Chicago Council in perfecting the plans have been Chairman J. J. Kanter, Vice-Chairman J. de N. Macomb, and Secretary G. E. Stryker. W. L. Bowler, The Pure Oil Co., and D. L. Colwell, Apex Smelting Co. are devoting considerable time and effort to the meeting.

Glee Club.—The New Trier Township High School Glee Club which will furnish the first portion of the program is one of the leading musical organizations of its kind. The high school located at Winnetka, Ill., is an outstanding institution, and a very active program in the field of arts including music is maintained constantly. The musical clubs have appeared before numerous organizations both around Chicago and other locations. Recently, they gave concerts at the Chicago Sunday Evening Club, the Illinois Manufacturers' Association at Springfield, Ill., and at a convention in Cleveland.

Flowers in Action.—The other portion of the program planned by the Council is to be given by John Nash Ott, Jr., who for 20 years has been perfecting a method of portraying "Flowers in Action" which is the title of his film and lecture.

Mr. Ott's sound color film explains what time-lapse means to the botanist—how plant growth of days, weeks, and months can be observed with scientific accuracy in motion pictures within a matter of moments. Many varieties of common and rare plants grow from seedling to maturity before your eyes through the magic of time-lapse photography presenting the flower's life cycle in exquisite color.

There is a sound color film titled "Plant Oddities," showing plants that live on air, plants that eat insects, and plants with extra sensitive nervous systems. "The Ballet of Flowers" is a sequence of dancing flowers which Mr. Ott accomplished by controlling the light, temperature, and moisture so that the interrupted growth and unusual motion thus obtained is set to the rhythm of a Strauss waltz. It required five years of painstaking effort to produce this charmingly different botanical finale.

In the process of developing and perfecting this photography, he learned that pictures had to be taken every five minutes which required a shutter arrangement to admit sunlight in order that plants might have their normal growth, but which must close when the pictures were being taken, in order that the scenes would have consistent lighting effect—that it took not one but sometimes several of his special cameras to obtain the desired effects. This also necessitated creating his automatic timing devices so that the clock which operated the shutters turned on the floor lights, snapped the camera, watered the flowers, and adjusted the height of the camera as the plants grew, so that Mr. Ott, the banker, who took up photography as a hobby, became not only a horticulturist but a carpenter, electrician, musical conductor, inventor, and lecturer.

1949 Annual Meeting News

Atlantic City, June 27–July 1

IN THE range of technical symposiums and subjects to be covered at the 1949 Annual Meeting in Atlantic City during June, there will be topics of interest to almost everyone in the Society. This meeting, to be at Chalfonte-Haddon Hall throughout the week beginning June 27, 1949, will again focus attention on the tremendous amount of work being done in the field of materials.

It is expected there will be hundreds of meetings of the Society's technical committees, many of them putting last minute touches on specifications and tests so that they will be as complete as possible for inclusion in the big new 1949 Book of Standards that will be issued late in the year. This book, as announced, is to be in six parts and its publication will entail the combined efforts of the committees and their officers and the staff.

Technical Sessions:

In the December BULLETIN there were a few notes on some of the following symposiums and technical discussions that are planned:

Symposiums on:

- Accelerated Durability Tests of Bituminous Materials
- Testing of Cast Irons with SR-4 Type of Gage
- Ultrasonic Testing
- Sleeve Bearing Metals and Their Lubricants
- Exhaust Valve Burning
- Radiography

In addition to these topics there will be other distinct sessions devoted to the following subjects:

Symposium on the Relations of Performance of Stainless Steels in Evaluation Tests to Performance in Service:

This subject is being sponsored by Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. Two sessions are being allotted for the presentation of the several papers comprising this symposium. It is felt that this will be a very worth-while symposium and more detailed information regarding it will be available at a later date.

Session on Water:

A Round-Table Discussion on Water is being sponsored by Committee D-19 on Industrial Water. The subject is "The Need for Standards for the Examination of Water-borne Wastes."

Session on Soils:

Committee D-18 on Soils for Engineering Purposes is planning on sponsoring a session on soils which will consist of 3 or 4 papers.

"Storied" San Francisco[1]

● OFTEN called "The Eternal City of the Western Hemisphere" by its inhabitants, many stories shroud San Francisco with myth and romantic conjecture. Starting with the fabulous stories of early Spanish explorers and extending through those of the even more fabulous stories of the '49ers and the Gold Rush, the 100th anniversary of which is being celebrated this year, the city is surrounded by an impression which time cannot efface. Perhaps it might be called "individuality."

● Just as San Francisco, in its more subtle lights and shadows reflects today the color of the Gold Rush, so do certain aspects of its life portray the enduring influence of its location. Set inland, even a hundred miles, though risen to its present size and influence, it could not be the city that it is. For the winds that, all these years, have swept in from the vast reaches

[1] Based on information and material from the Chamber of Commerce.

NATIONAL A.S.T.M. WEST COAST MEETING

October 10–14, 1949

Hotel Fairmont, San Francisco, Calif.

Technical sessions: Statistics; Ceramics; Concrete products; Dynamic Stress Determinations; Formability and Creep of Metals; Fatigue of Metals; Paints; Soils; Petroleum Products; Wood; and Others.

Various A.S.T.M. Technical Committees Will Meet. (Further details in subsequent BULLETINS)

of the Pacific have brought with them some of the quintessence of all the lands and peoples lying near and far beyond. And the ships that come and go—every ship that has sailed into San Francisco harbor, from the tiny barque San Carlos in 1775, down to the swift, modern ocean liners, has brought in something that could not be denominated on any manifest or bill of lading—something more than "goods and wares and merchandise."

● The life story of San Francisco in no small way is the story of ships and shipping. Of the Russian ships that in the early 1800's came from the Russian settlement farther up the California coast, to seek seals and sea otters in the waters of San Francisco Bay. Of the whalers that early made San Francisco their home harbor. Of the ships that came to supply the needs of the sprawling Gold Rush village and continued, to serve the city into which that sprawling village quickly grew. Of the "flying" clipper ships that raced each other, 'round Cape Horn for fastest transit time, New York to San Francisco, and whose grace of line and white-winged beauty painting and poetry have immortalized. Of the ships that brought in silks and tea and spices, and myriad things of strange beauty, from the Orient. Today, it is hard to realize what a ship's arrival and departure meant to San Franciscans one hundred years ago. It meant so much that they built a huge semaphore atop their highest hill, Telegraph Hill—where stands today the Coit Memorial tower—to signal to the eager, waiting throngs first sight of a ship coming through the Golden Gate.

Courtesy San Francisco Convention and Tourist Bureau

San Francisco is a City of Breath-taking Views. Here, Tall Telegraph Hill Looks Over Alcatraz to the Marin County Shore.

● Even on land, San Francisco was early served by "ships." Her first overland emigrants came in 1849 by covered wagon, or, as more romantically named, "prairie schooner." Four months it took them to complete the "voyage," and tales of their hardships and their heroism would overrun a volume.

● Other early land transportation that linked San Francisco with the east was provided by the famed Butterfield Stage Line, which made the trip from St. Louis to San Francisco in twenty-one days. Then came, in 1858, the thrilling, never-to-be-forgotten Pony Express. The story of the Pony Express—nearly a hundred fearless riders and some five hundred tough, sure-footed horses—is one packed with astonishing drama. These men and their faithful horses, riding in relays, always at top speed, always in incredible danger, fought and conquered snow and rain and raging blizzard, blistering desert heat and Indian bandits, so that early San Franciscans might get their eastern letters in twelve days.

● However, even this was not enough. Four Californians planned to build a transcontinental railroad from San Francisco. Begun in 1863 in the midst of the Civil War, this great undertaking, linking west and east forever, was finished in six years. On May 10, 1869, the last spike was driven—a spike of pure gold.

● Old San Francisco lives through the stories and memories of Mark Twain and his *Jumping Frog of Calaveras County*. Of Bret Harte, who founded in San Francisco his world-famous *Overland Monthly*. Of Robert Louis Stevenson and his *Silverado Squatters*—the shy and fragile "R.L.S." to whom adoring San Francisco built a monument in its Portsmouth Square. Of Jack London, with his snarling *Sea Wolf* and his plaintive *Call of The Wild*.

● To celebrate the completion of the world's two greatest bridges, and to commemorate another quarter-century of steady progress, San Francisco, in 1939 and 1940, sponsored the Golden Gate International Exposition and was host to millions of visitors from every corner of the world.

● Today San Francisco—a civic and recreational center of the "Golden West"—extends a hearty welcome to visitors, among whom will be those with the "pioneer" spirit in the stimulation of A.S.T.M. activities on the West Coast at the National Meeting of October 10–14.

Aerial View of San Francisco, Showing Both Bridges. Alcatraz on Extreme Right in Bay.

Courtesy San Francisco Convention and Tourist Bureau

Recent Actions on Standards

Steel, Aluminum, Glass, Roofing Materials, Electrical Insulating Materials

DURING December and January the Society's Administrative Committee on Standards approved a number of recommendations affecting various specifications and tests as indicated in the accompanying table. These actions involve both new and revised tentatives and proposed revisions of formal standards. The latter, however, will not affect the standards until adopted either later this year or in 1950.

Steel

The revisions in the end quench test for hardenability (A 255) are not extensive. In two places reference to the logarithmic S.A.E. chart is being deleted, since the logarithmic chart is being discontinued. A substance change modifies the cooling rates for the standard test bar to bring them in line with the latest information. On the chart there are given for various distances from the end of the standard bar approximate cooling rates in degrees Fahrenheit per second at 1300 F. These new cooling rates range from 490 at $\frac{1}{16}$ in. up to 3.1 at the other end of the chart, which is $\frac{40}{16}$ from the water-cooled end. Revised hardenability charts have just been published. A facsimile of the new chart with some ample curves is shown.

The alloy steel pipe specification (A 158) has been changed by the deletion of the grade P6, since this 13 per cent chromium composition is indicated as no longer in commercial production.

Two new grades B8 and B8F, austenitic stainless steel, are being added to the specification for alloy steel bolting (A 193). These grades are covered in the cold-drawn conditions, one being stabilized, the other B8F has no stabilizing elements. Tensile strengths range from 100,000 to 125,000 psi., depending upon size, with yield point from 50,000 to 100,000 psi. Elongation in 2 in. ranges from 12 to 28 per cent.

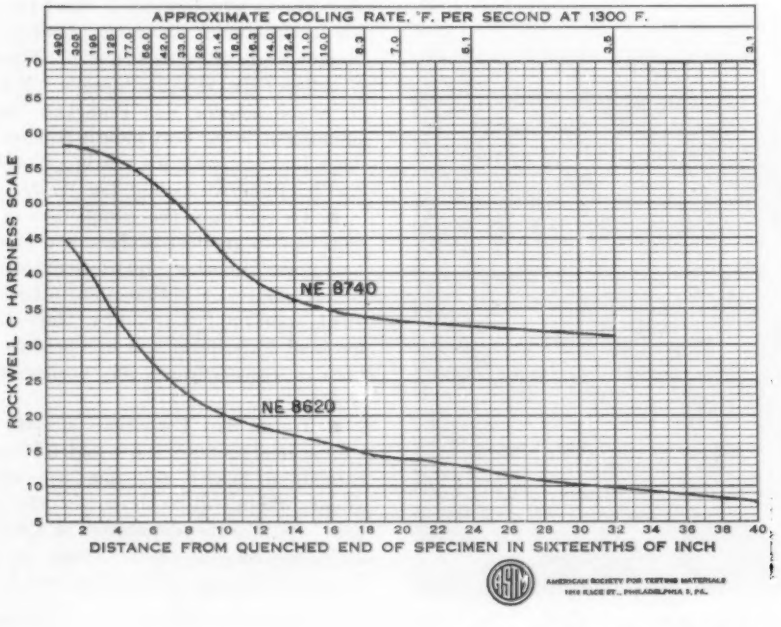
The change in the nut specification (A 194) provides two new grades of austenitic material to correspond to the bolting grades being added to A 193.

A. S. T. M. END QUENCH TEST FOR HARDENABILITY OF STEEL (A 255 - 48 T)

DATE_____
LABORATORY_____
TYPE SPECIMEN_____
TEST NO _____

TYPE	HEAT NO.	GRAIN SIZE	C	Mn	P	S	Si	Ni	Cr	Mo		NORM. TEMP. °F.	QUENCH TEMP. °F.
Ne 8740	19297	8-7	.44	.89	.019	.016	.27	.58	.50	.25		1650	1500
Ne 8620	621271	7-8	.19	.80	.015	.015	.23	.46	.52	.22		1700	1550

REMARKS:



Actions of A.S.T.M. Administrative Committee on Standards, December, January, 1948–1949

New Tentatives

Specifications for:
- Aluminum Alloy Extruded Tubing (B 235 – 48 T)
- Aluminum-Alloy Drawn Seamless Tubes for Condensers and Heat Exchangers (B 234 – 48 T)
- Sieve Analysis of Roofing Granules (D 1001 – 48 T)
- Aluminum Bars for Electrical Purposes (Bus Bars) (B 236 – 48 T)

Method of:
- Testing Pressure Sensitive Adhesive Tapes Used in Electrical Insulation (D 1000 – 48 T)

Definitions:
- Terms Relating to Glass and Glass Products (C 162 – 48 T)

Tentative Revisions of Standards

Specifications for:
- Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service (A 194 – 48)

Methods of:
- Testing Pasted Mica Used in Electrical Insulation (D 352 – 39)

Definition of Terms:
- Relating to Materials for Roads and Pavements (D 8 – 46)

Revision of Tentatives

Specifications for:
- Seamless Alloy Steel Pipe for High-Temperature Service (A 158 – 48 T)
- Alloy-Steel Bolting Materials for High-Temperature Service (A 193 – 47 T)

Methods of:
- Testing Asphalt Roll Roofing, Cap Sheets, and Shingles (D 228 – 47 T)
- End-Quench Test for Hardenability of Steel (A 255 – 46 T)
- Methods of Sampling and Testing Untreated Paper Used in Electrical Insulation (D 202 – 47 T)

Aluminum

There has been an expressed demand for standardized purchase requirements for aluminum condenser and heat exchanger tubes, and also for aluminum bus bars, and the two new specifications B 234 and B 236, respectively, will meet these requests. Two types of aluminum alloy seamless condenser and heat exchanger tubes are covered, designated alloy M1 and M1 clad. Minimum tensile strength is 19,500 psi., the yield strength 17,000 psi. The specifications indicate that the two types of alloys are of the strain-hardening class and must be supplied in an intermediate temper.

The bar specification (B 236) involves rolled or rolled and drawn rectangular bars for use as electrical conductors (bus bars). Minimum aluminum content is 99.45 per cent. Tensile requirements range depending on thickness from 12,000 to 17,000 psi.

The tensile requirements for aluminum alloy extruded tubing (B 235) range from 80,000 minimum psi. down to 19,000 psi. max. varying according to the six alloys covered, as well as the temper and cooling thickness.

Definitions of Terms Relating to Glass

Eleven terms are covered in standardized definitions which will be added to the definitions of the term "glass" in the tentative C 162. The following are covered: annealing point; chemical durability; cord; deformation point; fining; liquidus departure; melting; melting temperature; setting rate; softening point; and working range.

Definition of Terms Relating to Road Materials

Quite a number of terms relating to materials for roads and pavements have been under study in Committee D-4 and as a result the proposed revisions have been approved for publication. Terms for which proposed changes are established cover: bituminous material; bituminous emulsion; cut-back products; flux; asphalt; asphalt rock (rock asphalt); and water-gas tar. It is proposed to delete the definitions of three terms, namely, petroleum, dead oils, and matrix.

Roofing Materials.

The specification for sieve analysis of roofing granules (D 1001) meets the demand for grading of granules used on prepared roofing.

In the tentative methods of testing asphalt roll roofing, cap sheets and shingles, (D 228), there have been deleted the requirements that only die-cut specimens would be used for analysis.

Electrical Insulating Materials

For several years a section of Committee D-9 has been working on test procedures for so-called sensitive adhesive tapes, which could be used in electrical insulation. This material includes so-called "scotch" tape, and others except friction and rubber tape. Requirements in D 1000 are given on conditioning, thickness, dielectric strength, etc. Other requirements relate to storage stability, and measurement of electrolytic corrosion.

The changes in methods of sampling and testing untreated paper (D 202) involve the impregnation time, with clarification of the penetration tester that is used.

In the methods for testing pasted mica (D 352) there is a minor change in the procedure for determining mica or binder content.

More Publications

SEVERAL additional A.S.T.M. publications have been issued since the December BULLETIN where there were given notes on a number of important new books. The 1948 Supplements to the Book of Standards have been completed and all Parts which the members have requested should be in their hands shortly. The special compilation of standards covering Steel Piping Materials has been completed and the book which gives all the specifications and tests pertaining to Electrical Insulating Materials is nearing completion.

Notes on these and certain other technical publications including the interesting Marburg Lecture on "Isotopes and Their Application in the Field of Industrial Materials" follow.

1948 Supplements to Books of Standards

Supplements to the Books of Standards are issued in the years between publication of the big books. Thus, there was a 1947 Supplement to *each* Part of the 1946 Book, and the 1948 Supplements are in course of distribution. There is a 1948 Supplement in blue heavy paper binding for *each* of the five Parts of the Book of Standards as follows:

1948 SUPPLEMENTS:

I-A—Ferrous Metals
I-B—Nonferrous Metals
II—Nonmetallic Materials—Constructional
III-A—Nonmetallic Materials—Fuels, Petroleum, Aromatic Hydrocarbons, Soaps, Water, Textiles
III-B—Nonmetallic Materials—Electrical Insulation, Plastics, Rubber, Shipping Containers, Paper, Adhesives

These Supplements include all new *tentatives* and *revised standards* on which action was taken during 1948 and they also include in the back portion of each the *proposed revisions* of standards, these revisions being published as information and for comment before final adoption into the standards. Each Supplement has a table of contents listing material by fields covered and a second list is in the sequence of designations of the items. Tentative revisions of standards are noted in a separate table of contents. The 1948 Supplements will range in size from 200 to 450 pages.

Each member gets the corresponding Supplements to the Parts of the Book of Standards he has obtained and for which instructions are on file at Headquarters.

The Supplements are available to nonmembers at $4 per copy and members can procure extra Supplements at $3 each, the total for the five Supplements being $20 and $15, respectively.

Steel Piping Compilation

Committee A-1 on Steel has a number of very active subcommittees covering the rather clearly marked fields of products. No groups have been more active than Subcommittee IX on Pipe and Tubing and Subcommittee XXII of Materials for High-Temperature Service, the latter group including in its work pipe, castings, bolting, and forgings used in connection with piping and related installations.

A complete compilation of all A.S.T.M. Standards on Steel Piping Materials has been issued periodically, and the new edition carrying a December, 1948, date is a 330-page book including some 50 specifications. Of these 17 cover various types of pipe—welded, seamless, and carbon and alloy; 13 specifications relate to boiler, superheater, and miscellaneous tubes; six cover the field of steel tubes and heat-exchanger and condenser tubes. Of the balance five specifications cover carbon and alloy-steel castings for various types of service and applications; four relate to forgings and welding fittings; three cover bolting and the useful grain size standard covering austenite grain size in steels (E 19) completes the book.

Several of the specifications were changed in 1948; certain new ones have been added, and a major review by T. G. Stitt, the active chairman of Subcommittee IX on Pipe, and his associates, has resulted in numerous editorial improvements in the pipe standards.

Copies of this widely used compilation can be procured by the members at $2.25, the list price being $3. Reduced prices are in effect on orders in quantity.

Electrical Insulating Materials

This compilation is one of the most extensive issued by the Society, and when it is considered that there are more than 90 specifications and tests in this field it is not surprising that the latest edition of the compilation dated January, 1949, should extend to over 600 pages.

In addition to the standards, there is considerable other supplementary material, including specially prepared reports on the significance of tests of insulating materials, for example, the dielectric strength test, impact, tensile strength, power factor test, etc., and there is a detailed subject index—very helpful because of the wide range of materials and subjects in this field.

Some idea of the subjects covered in this standardization work of the Society may be had from the accompanying table:

- Varnishes, Paints and Lacquers—6 specifications
- Plates, Sheets, Tubes, Rods and Molded Materials—37
- Mineral Oils for Electrical Insulation—10
- Ceramic Products—6
- Solid Filling and Treating Compounds—2
- Insulating Fabrics—6
- Insulating Papers—3
- Mica Products—4
- Electrical Tests—6
- Rubber Products—4
- Textile Materials—10
- Miscellaneous, Servicing Units, Conditioning, pH Value Test—5

Members can procure this book at $3.40 per copy, list price, $4.50.

Marburg Lecture—Isotopes and Their Application in the Field of Industrial Materials

The published 1948 Edgar Marburg Lecture has been awaited with interest by a large number of those concerned with the field of materials. Dr. Paul C. Aebersold, Chief, Isotopes Division, U. S. Atomic Energy Commission, Oak Ridge, Tenn., has written a lecture that is most timely, covering the subject of isotopes and their application in the field of industrial materials.

In the May BULLETIN it is pointed out that the advent of these isotopes has been a most constructive contribution to science resulting from nuclear research and that while these radioactive materials are only one of several kinds of fruit ripening on the tree of atomic energy they are beginning to be used rather widely.

Following some general comments pointing to the significance and interrelation of atomic energy and industrial materials where he stresses among other things that science and industry are mutually dependent for progress and support and are stimulating to each other, he discusses general research dividends, useful atomic power, induction of chemical and physical effects, and finally in some detail the applications of radioactive and stable isotopes. He points out that radioisotopes of most of the elements can now be made in the atomic pile and that production at Oak Ridge is sufficient to meet our domestic needs with some over.

Essentially the usefulness of radio isotopes comes from two facts—first, they exhibit the same chemical behavior as the stable species of the elements, and of course, secondly, they emit radiations which will determine their identity and location. The author covers isotope properties, production, and measurement, with pertinent references to facilities and safety precautions, and there is a section devoted to the basis for isotope applications. Quite a portion of the lecture covers the use of these materials as tools for analysis with numerous specific applications. There is discussion of stable isotopes, and the lecture closes with general conclusions, the closing paragraph reading as follows:

"You, who have special scientific and technical knowledge, can of course do much to study the problems and facts, on both the constructive and destructive aspects, and keep yourself and your friends well informed. Next, through our democratic procedures and representation you can urge wide and vigorous support of the measures developed by our well-tested, common-sense methods of unbiased reasoning. Finally, you can help to master the fears in yourselves and others, which if allowed to go uncontrolled may shake our faiths—our faiths in each other, in our way of life, in our free-enterprise system, in our form of government, in our spiritual and moral beliefs—for it is in these faiths, as much or more than in our mighty weapons and technology, that we are truly strong and capable of leading the world to peace and greater human welfare."

The lecturer, Dr. Aebersold, has included a Bibliography of more than 77 useful references and numerous illustrations.

This lecture will be printed in the 1948 *Proceedings*, but in advance the lecture is available in separate pamphlet form to members at 75 cents, the list price being $1.

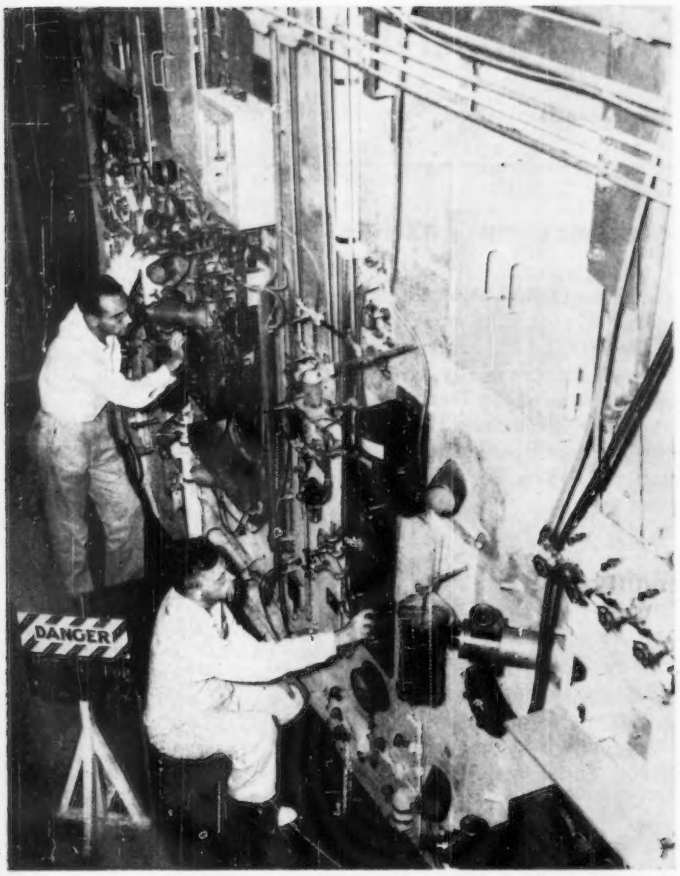
Bulletin to Appear Eight Times Yearly

Seven Issues in 1948; Advertising Rates Modified

EFFECTIVE in July, 1948, the ASTM BULLETIN will appear eight times a year instead of on the six issue per year basis that has been in effect since the late 1920's. This expansion in the number of issues is in line with the recommendations of the Administrative Committee on Papers and Publications, and the Board of Directors, to have more frequent contact with the membership, and at the same time provide increased facilities for bringing the continuing larger volume of technical papers and related material to the membership.

The regular three BULLETINS will be published during the first six months, namely, January, March, and May; but during the last half of the year there will be July, September, October, and December issues. The following year (1950) there will be January, February, April, and May issues. These eight BULLETINS are to be staggered so that the intervals between are approximately the same. Further announcement will be made concerning the approximate mailing dates which can be anticipated. (With considerably better conditions at the printers, and some relief on the Editorial Staff at Headquarters, it is hoped the BULLETINS can now go in the mails closer to the mailing schedule then has been the case during the war and recent years.)

There is a general feeling on the part of the membership that interest and readability of the BULLETIN will be diminished if it is too large. During



Two operating chemists at controls and periscopes view chemical process for separating the dangerously radioactive fission products of uranium. The operators are protected by thick concrete and lead.

the past few years the number of pages have been about 100 per issue, and on the new eight issue basis about this same size will continue.

Advertising:

Effective with the March, 1949, issue, advertising rates will be modified in recognition of the increased distribution of the BULLETIN, not only through a larger membership but also more subscribers; and in part to enable granting of the 15 per cent agency commission, which most business papers now have in effect. The new rates will be $145 for a full page, on the basis of a page in each BULLETIN; the corresponding half-page rate will be $87.50; and the quarter page $52.50. The rates were discussed with a number of organizations and agencies which have been using the BULLETIN for years, and their viewpoints and counsel were carefully considered in the new rate structure.

The income from advertising in the BULLETIN is important in the Society's financial operations, although the BULLETIN is definitely not a money-making venture. The objective is to insure covering the mechanical costs of publishing and mailing the publication.

The distribution of the BULLETIN, the quantity and the quality of the readers, is a very unique and pertinent one for manufacturers and distributors of laboratory supplies, testing and scientific equipment, and related information; and also for announcements of the services of professional testing laboratories. *Conversely*, the advertising pages of the BULLETIN will continue to provide the membership with current information on new and improved equipment and laboratory supplies not only for the testing and evaluation of materials, but for many research activities, and a multitude of other fields in which the A.S.T.M. membership is engaged.

The advancements in the science of evaluating materials, and developing new products and processes, are intimately linked with the progress of the instruments and apparatus industries. The growth of this industry itself is a reflection of its importance. The continuing development of new instruments, many of them necessary in the use of A.S.T.M. specifications and tests, and frequently the basis of BULLETIN advertising, is in part a reflection of the technical progress and initiative of those in the apparatus field.

Bulletin Statistics

While the membership and those who read the BULLETIN have not been plagued unduly with statistics and data, some data may be of interest. The following table will indicate the BULLETIN growth.

YEAR	TOTAL PAGES	COPIES PRINTED
1926	40	...
1930	116	39,100
1935	132	35,380
1940	376	39,700
1945	500	47,200
1948	688	60,600

Technical papers and formal reports, and related material, began to appear in the BULLETIN, which previously had been a strictly news medium, in 1934. For the next five to six years there was a somewhat gradual increase in the volume of technical material published, but there has been a marked growth in the past few years. Each issue of the 1947 and 1948 BULLETINS included from six to ten papers and technical articles. These papers are carefully studied by competent reviewers in the Society, are approved by the Committee on Papers and Publications, and are edited with the same close scrutiny with which all A.S.T.M. material is prepared, and eventually issued to the membership. An effort is made in considering and accepting papers for the BULLETIN, as well as the *Proceedings*, to keep carefully in mind the interest and activities of the members. The Society has enjoyed an enviable reputation as an authoritative forum, through its meetings and publications, for the discussion of properties and tests of materials. The ASTM BULLETIN occupies an important place in the Society's publications scheme. The expansion from six to eight issues, plus other mechanical improvements, is aimed to make the publication as pertinent and as valuable as possible.

Preparing Irradiated Unit for Shipment

Textiles on The International Front

ISO Committee 38—European Research and Standardization—Wool Conference

Report on ISO Conference on Textiles

The meeting of the International Standards Organization (ISO), Technical Committee 38 on Textiles, was held at Buxton, England, June 7 to 12, 1948. There follows a description of the ISO and the general proceedings and events prior to the Conference, and then, specifically, the discussion that took place with reference to various aspects of the Testing of Fabrics. The several sections of this report have been prepared by H. J. Ball, G. S. Buck, J. B. Goldberg, and A. G. Scroggie as participants in the Conference and as a report to the Society's Committee D-13 on Textiles at its meeting on October 14, Washington, D. C.

Organization of ISO and Technical Committee 38

Contributed by J. B. Goldberg[1]

Organization and Membership of the ISO:

THE International Organization for Standardization, commonly referred to as the "ISO," was formed in October, 1946, and was recognized as a nongovernmental body by the Economic and Social Council of the United Nations, succeeding the International Standards Association which was in existence before the last war. Membership is comprised of the national standardizing bodies of 26 nations. The United States is represented by the American Standards Association which contributes $8000 annually of the approximate total of $50,000 furnished by all participating nations. The purpose of the ISO is to try to effect coordination of national standards in any given field so as to eliminate as much as possible the differences among the various national standards.

Methods of Functioning:

The operations of the ISO are carried out through triennial meetings of the General Assembly in which all members are represented. Interim meetings of the Council on which there are represented eleven nations are held annually, the first such meeting having been held in Zurich in 1947.

Any member body may suggest the establishment of a Technical Committee or the initiation of a project in the field of an existing committee. If at least five member bodies desire to participate and if there is no objection on the part of the majority to the initiation of the project, it is then undertaken and assigned to an existing committee or one formed for the purpose. One of the member bodies is designated by the Council to assume the duties of the Secretariat.

Duties of Secretariat:

The Secretariat's responsibility is to keep the work of the Technical Committee moving, to collect and distribute documents pertaining to the subject and to analyze the differences in existing national standards so that committee members may have an opportunity to eliminate such differences wherever possible. When the Technical Committee has reached an agreement on recommendations to be made, by correspondence or balloting in a meeting, a report embodying the agreements is transmitted to the General Secretary of the ISO at Geneva for distribution to all member bodies. The views of all members are then reported to the Council which may approve the publication of an ISO recommendation or, if there be no dissenting vote, they may authorize publication of an International standard. If circumstances warrant further breakdown of responsibilities, technical subcommittees may be established with individual Secretariats designated. These subcommittees assemble and coordinate data on the specific project assigned to them and transmit their report to the permanent Secretariat of the Technical Committee concerned.

Technical Committee 38 on Textiles:

At the Council meeting in Zurich in 1947 it was agreed that the permanent Secretariat of Technical Committee 38 on Textiles would be assigned to either the United States or the United Kingdom, the resolution of the question being left to those two nations. The British Standards Institution temporarily assumed the Secretariat and took the initiative in arranging the conference which was held in Buxton, England, last June.

The American Standards Association had proposed that the assignment of the Secretariat be made to the U.S.A. The chief reasons cited for making this request were as follows: (1) The United States is the only country which produces and processes all the major textile fibers from fiber to finished product; (2) the development of textile test methods has moved forward to a greater extent in the United States than in any other country; (3) the large production programs of the armed forces during the last war resulted in the accumulation of a vast amount of information regarding test methods; and (4) the large number of national technical groups as well as textile schools and commercial and nonprofit foundations and research organizations indicates the broad scope of the textile industry in the United States.

The United States delegation, set forth below, therefore went to Buxton with the full intention of requesting the assignment to this country. At the same time it was recognized that the British Standards Institution was already well organized and equipped to carry out the duties involved most efficiently. The BSI has already undertaken the Secretariat of eleven projects under the ISO and has an operating staff for conducting the affairs involved in an experienced and able manner. A British Committee selected by the Institution performs a voluntary service without compensation in general supervision of the Secretariat, arranging

[1] Director of Research, J. P. Stevens & Co., Inc., New York 13, N. Y.

meetings, programs of proceedings and reports to the Council of the ISO. Operating expenses are provided for from the general funds of the BSI.

A statement was prepared by our chairman, Mr. Douty, and Vice-Admiral G. F. Hussey, Jr., Secretary of the ASA, to present the views of the United States delegation. The main points stressed were that the textile project would probably be one of the most diversified thus far undertaken by the ISO, and it could well become one of the largest as well as most costly to conduct. Therefore, it was suggested that during the early years of activity, at least, there would be required the full time of a competent technical secretary with clerical experience and some language requirements. It was also proposed that an executive committee of ten or twelve individuals representing producers, consumers, distributors, and others with general interest should be chosen to act under the chairmanship of an outstanding public-spirited textile executive. In addition, we suggested that there be formed an international advisory committee consisting of an outstanding textile technologist from each country having sufficient textile production and activity in textile standardization to justify its nominating a qualified representative. This international advisory committee could become an executive committee to which important matters could be referred. In conclusion, we stated that if the United Kingdom would like to accept the permanent Secretariat on this basis, and with the understanding that we would be critical of its operation as well as cooperative to the best of our ability, we would go along with them. On the other hand, if they thought that our suggestions were too elaborate and specifications too exacting we would be glad to take it on, welcoming the same cooperation that we would extend to them. These proposals were submitted at a joint meeting with the British delegates for their consideration. The following day, the chairman of the United Kingdom delegation notified us that they were willing and ready to accept our proposals and the permanent Secretariat of Committee 38 on Textiles. The agreement was reported to all delegates at the next general session.

It now remains for us to exhibit more than a casual interest in the operations of this Secretariat, to cooperate fully in achieving complete harmony on standard international test methods and terminology, and to encourage the appointment of specific groups of technical men to undertake the responsibilities which have been assigned to us.

At British Textile Institute Meetings: top row, l. to r., J. B. Goldberg; D. E. Douty, Chairman, American Delegation; and at the right, Dr. Carl M. Conrad. Lower row, second from the left, Prof. H. J. Ball; third from left, J. Foster Beaver, President, British Textile Institute. Fourth from left in upper row is Prof. Emil Honegger, Swiss delegate to the ISO Conference

Photo courtesy Dr. W. J. Appel

General Proceedings

Contributed by H. J. Ball[2]

THE announcement of the meeting with its tentative agenda and the invitation to send a delegation from the U. S. was transmitted through the American Standards Association in the early part of the year (1947) to all organizations concerned. Interest crystallized rapidly, and on April 23 the ASA called a preliminary meeting in New York of those who by that date had been chosen by their respective organizations to go to Buxton. The names of the 14 individuals who composed the U. S. delegation and the organizations they represented are as follows:

D. E. DOUTY, Chairman of Board, United States Testing Co., Inc.; designated by American Council of Commercial Laboratories, National Federation of Textiles, Inc., and New York Board of Trade; *Chairman.*

WILLIAM D. APPEL, Chief, Textiles Section, National Bureau of Standards; designated by the Bureau.

H. J. BALL, Head of Textile Engineering Department, Lowell Textile Institute; designated by the American Society for Testing Materials.

J. ROBERT BONNAR, Technical Director, General Dyestuff Corp.; designated by American Association of Textile Chemists and Colorists.

FREDERIC BONNET, American Viscose Corp.; designated by American Association of Textile Technologists, New York Board of Trade, National Retail Dry Goods Association.

GEORGE S. BUCK, National Cotton Council; designated by the Council.

CARL M. CONRAD, Southern Regional Research Laboratory, U. S. Dept. of Agriculture; designated by the Bureau of Agricultural and Industrial Chemistry.

J. B. GOLDBERG, Director of Research, J. P. Stevens & Co., Inc.; designated by American Association of Textile Technologists, Inc., National Federation of Textiles, Inc., Textile Research Institute; New York Board of Trade.

JOHN I. HARDY, Senior Animal Fiber Technologist to the Bureau of Animal Industry Agricultural Research Center, U. S. Department of Agriculture; designated by U. S. Department of Agriculture.

VICE ADMIRAL G. F. HUSSEY, JR., USN (Ret), Secretary, American Standards Association; designated by the Association.

EDWARD T. PICKARD, Secretary, The Textile Foundation; designated by The Textile Foundation, The Textile Research Institute.

A. G. SCROGGIE, E. I. du Pont de Nemours & Co., Inc., Rayon Department; designated by the American Society for Testing Materials.

C. D. THOMPSON, Ensign-Bickford Company, Simsbury, Conn.; member of Committee D-13, American Society for Testing Materials; adviser on bast fiber products.

D. L. WORF, Office of Naval Research, U. S. Navy; designated by Office of Naval Research.

At the preliminary meeting, the organization of the delegation was initiated by the choice of D. E. Douty as chairman, and H. J. Ball as vice-chairman. The tentative agenda of the meeting was examined for the purpose of developing the American point of view and ten subcommittees were appointed to deal with the various phases of the conference program. A second and final meeting of the delegation was held in New York City on May 11, one day before the date of departure of those who were first to leave.

Some members of the delegation arrived in England in sufficient time to attend the annual meeting of the British Textile Institute which was also held in Buxton, June 2 to 5, inclusive, of the week preceding the ISO meeting. This gave an opportunity to get acquainted

(Continued on page 26)

[2] Head of Textile Engineering Department, Lowell Textile Institute, Lowell, Mass.

ASTM Bulletin

JANUARY 1949

NO. 156

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

How An A.S.T.M. Standard Gets That Way

SINCE the chart outlining the A.S.T.M. standardization procedure was published in the BULLETIN several years back, a few changes have been made, and meanwhile there are a large number of new members who may not have seen the visual portrayal of the step-by-step procedure by which a proposed specification or test is processed and eventually published as a formal A.S.T.M. standard. It will be noted that there are essentially two broad divisions in the standardization procedure; one is the publication of "tentatives," which are proposed specifications and tests, published for a year or more prior to their adoption as formal standards. It will be noted that these tentatives go through a very rigorous procedure. The second broad division in the standardization setup involves advancing a "tentative" on the road to adoption as a formal standard.

While this chart may seem at first glance to depict a rather complicated process, the officers of the various technical committees, are well acquainted with the steps, and the staff contact men and others at Headquarters are always available for guidance and advice.

Obviously, no chart can cover all of the Society's requirements and standardization steps, and reference should be made to certain basic elements in all A.S.T.M. work involving standards. A principle underlying the technical committees responsible for the specific fields of work is to have the personnel representative of the consumers and producers of the specific commodities, with a third so-called general interest group always represented on the committee. The necessity of having the best and latest information on all points bearing on a standard is constantly before the committees.

Taken all together—the complexion of the technical committees, the technical caliber and sympathetic understanding of those working in the committees, the excellent leadership through the committee officers, and the time-tested procedure through which a proposed specification or test must pass before publication, all support an interesting statement made some years ago by Past-President A. C. Fieldner that "The specifications, definitions, and methods of test should be used as standards because they are competent, unbiased, widely applicable, and authoritative."

(We might add that A.S.T.M. standards are not perfect; in fact, there are constant developments that indicate a need for review, clarification, or even correction. Taken as a whole, however, they are a good foundation and guidance on the properties and testing of materials. From another viewpoint they may be considered constructive and practical results of the cooperative and voluntary procedures embodied in A.S.T.M.)

New Sustaining Member

WE ARE pleased to announce the acquisition of Sustaining Membership by two organizations that have been represented and active in A.S.T.M. work for a number of years. These companies and their representatives are as follows:

Continental Oil Co., Ponca City, Okla.—L. L. Davis, Manager, Development & Research Dept.

The Glenn L. Martin Co., Baltimore, Md.—H. C. Engel, Chief of Engineering Laboratories.

In each case the Sustaining Member-

Schedule of A.S.T.M. Meetings

DATE	GROUP	PLACE
January 18–19	Committee E-3 on Chemical Analysis of Metals	Pittsburgh, Pa.
January 24–26	Committee A-1 on Steel	Pittsburgh, Pa.
January 31–February 1	Committee B-9 on Metal Powders and Metal Powder Products	Pittsburgh, Pa.
February 3	New York District	New York, N. Y.
February 10	Philadelphia District	Philadelphia, Pa.
February 14–18	Committee D-2 on Petroleum Products and Lubricants	Washington, D. C.
February 21	Detroit District	Detroit, Mich.
February 28–March 4	1949 SPRING MEETING (Mar. 2) and A.S.T.M. COMMITTEE WEEK	Chicago, Ill.
March 10	Western New York-Ontario District	Rochester, N. Y.
March 16–18	Committee D-13 on Textile Materials	New York, N. Y.
Week March 21	Committee D-9 on Electrical Insulating Materials	Washington, D. C.
Week March 21	Committee D-20 on Plastics	Washington, D. C.
March 22	Philadelphia District	Philadelphia, Pa.
April 5	New York District	New York, N. Y.
April 14	New England District	
April 29	Pittsburgh District	Pittsburgh, Pa.
May 9	Board of Directors	(A.S.T.M. Headquarters)
May 9–10	Committee D-10 on Shipping Containers	Atlantic City, N. J.
June 27–July 1	1949 ANNUAL MEETING	Atlantic City, N. J.
October 10–14	1949 WEST COAST MEETING	San Francisco, Calif.
October 19–21	Committee D-13 on Textile Materials	Philadelphia, Pa.

ship of the organizations noted has been effected by transfer from the Company to the Sustaining Membership class. At the present time there are over 200 A.S.T.M. Sustaining Members who through the payment of annual dues of $150 underwrite the Society's work to a degree somewhat more commensurate with the value to their wide-flung operations and their diverse interests of the A.S.T.M. work than would be the case with a straight Company Membership.

The Sustaining Members have the same privilege as do Company Members of designating different technically qualified individuals to serve on the various technical committees to which the companies may be elected. Each Sustaining Member receives a specially engrossed and distinctive membership certificate, and in addition to the regular A.S.T.M. publications the Sustaining Member may request a copy of any of the books which the Society issues. There is no entrance fee or transfer charge in the case of Sustaining Members.

A note to A.S.T.M. Headquarters will bring further information about some of the pertinent aspects of this class of Membership. The Board of Directors is appreciative of the interest and support of the companies which are A.S.T.M. Sustaining Members.

Inter-Society Color Council Seventeenth Annual Meeting

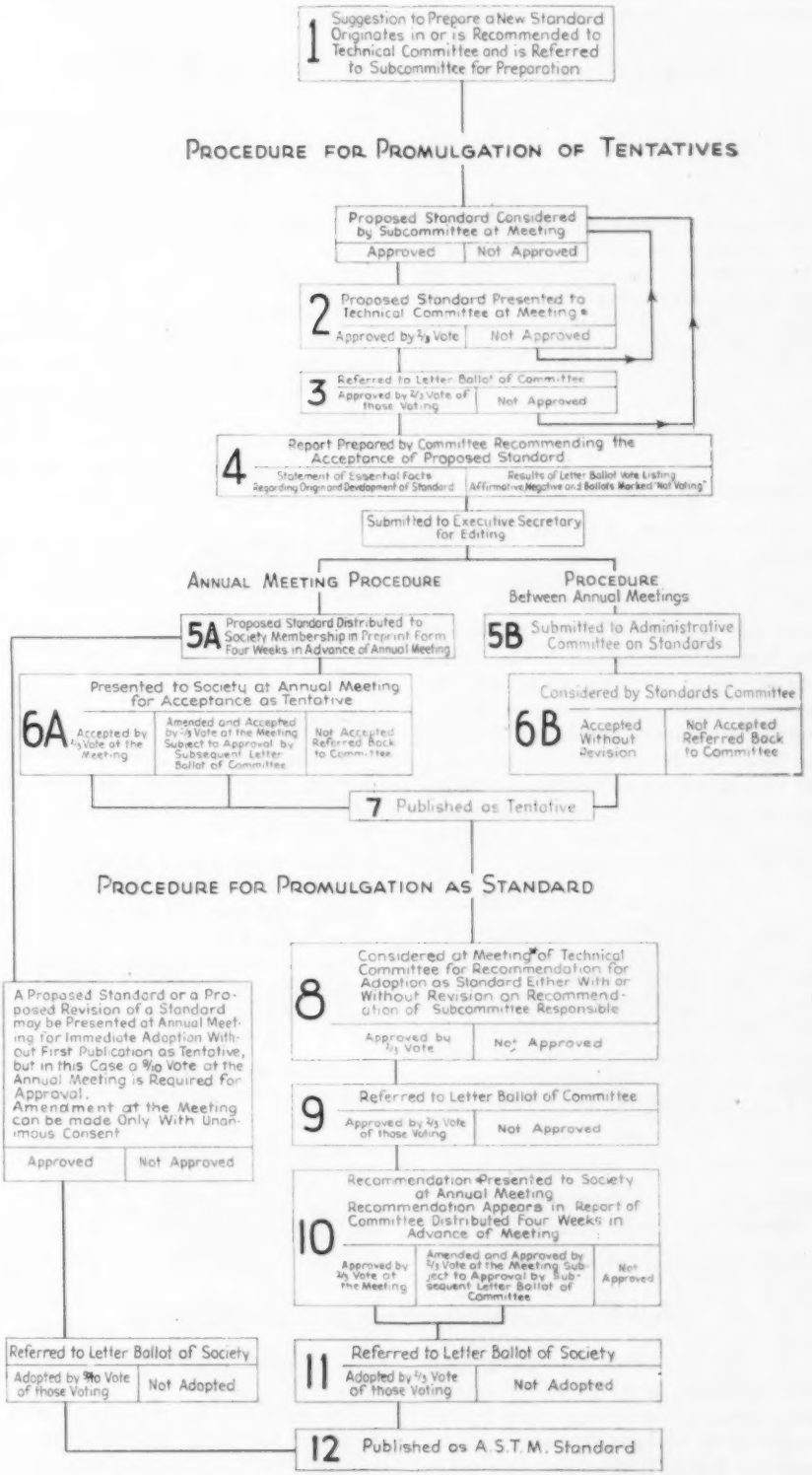
THE seventeenth annual meeting of the Inter-Society Color Council will be held on Wednesday, March 9, 1949, at the Hotel Statler (Pennsylvania), New York City. The meeting will consist of a Discussion Session at which committee chairmen will report on the following problems:

2—Color Names (Revision of), Deane B. Judd
6—Color Terms, Sidney M. Newhall
7—Color Specifications, Walter C. Granville
12—Studies of Illuminating and Viewing Conditions in the Colorimetry of Reflecting Materials, D. B. Judd
14—A Study of Transparent Standards Using Single-Number Specification, Robert H. Osborn

A Business Session will conclude the afternoon meeting. Anyone interested is invited to attend. Hotel reservations should be made directly to the hotel at least ten days prior to the meeting, indicating that you are attending the ISCC meeting.

A.S.T.M. is officially represented on the Council—the three voting delegates being Messrs. W. R. Brode, M. Rea Paul, and W. M. Cott; the non-voting delegates being A. G. Ashcroft, W. F. Bartoe, W. C. Granville, A. J. Kellner, F. S. Mapes, and B. S Van Zile.

OUTLINE OF STANDARDIZATION PROCEDURE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS



Recommendations may under certain conditions be submitted directly to letter ballot without action at a meeting.

Note.—Revisions of a standard follow the same procedure as a new tentative

DISTRICT ACTIVITIES

Interesting District Meetings to Be Held

BRIEF notes appear below on some of the interesting meetings planned by the respective A.S.T.M. District Councils. All members of the Society, committee members, and others interested are cordially invited to attend these sessions. Some of the meetings are designed to bring the President of the Society, and other prominent A.S.T.M. men, before the districts, and in all cases, the topics covered should be of distinctive interest to many A.S.T.M. members.

New York—February 3—Engineering Societies' Building, Room 501

At this meeting, A.S.T.M. President Richard L. Templin will present his address on the subject of Aluminum, but since the meeting is to be a joint one with the Machine Design Division of the Metropolitan Section of The American Society of Mechanical Engineers, he is expanding the address to include pertinent information and data of interest to those who design machine parts and equipment where aluminum is finding use, and where it will have application. The meeting is scheduled to get under way at 7:30 o'clock sharp.

....—*April 5 meeting on Sources of Energy.* The New Council is pleased to announce for its April 5 meeting in the Engineering Societies Building, that Dr. Eugene Ayres, Gulf Research and Development Co., will present his interesting address on the subject "Nine Major Sources of Energy." This subject will be of interest to every engineer and technical man. Further details will be announced.

Philadelphia — February 10 — McCallister's, 1811 Spring Garden St.

A two-session meeting is planned by the Philadelphia District on February 10, the subject being one of intensive interest, namely, Quality Control in Industry. Four technical papers are scheduled as follows:

Afternoon:

Organizing for Quality and Waste Control—Dr. Eugene H. MacNiece, Director of Quality Control, Johnson & Johnson, New Brunswick, N. J.

Study of Process Capabilities and Application at the Foreman's Level—Anthony Oladko, Foreman, Adhesive Plaster Mill, Johnson & Johnson, New Brunswick, N. J.

There will be a Dinner at 6:30 p.m., with General Donald Armstrong, President of U. S. Pipe and Foundry Co., as the speaker. His talk will be on the "Advantages of Quality Control from Top Management's Point of View."

Evening Session:

Mobilizing for Quality Control—Jos. M. Juran, Professor and Chairman, Department of Administrative Engineering, New York University.

Lecture and Training Film on Quality Control—Simon Collier, Director of Quality Control, Johns-Manville Corp., New York, N. Y.

This meeting promises to be one of the outstanding district affairs for the year, and a large attendance is expected.

....—*Industrial Stream Pollution—The Problem and Its Solution, at March 22 Meeting*

Two speakers at the meeting on March are outstanding in their fields. Dr. Norris W. Vaux, Secretary of Health, Commonwealth of Pennsylvania, will discuss the first phase of the subject, "The Problem," and Mr. W. B. Hart, The Atlantic Refining Co., will develop the subject of "The Solution." Further announcement will be made.

Detroit—February 21

At this meeting, President Richard L. Templin will be the chief speaker giving his illustrated address on the subject of Aluminum. Prior to his talk, which will be at the Rackham Building, there is to be a dinner and Mr. Austin Grant, newspaper and radio commentator, will speak.

Western New York-Ontario—March 10 in Rochester

Dr. Eugene Ayres, of the Gulf Research and Development Co., Pittsburgh, Pa., will be the technical speaker at the meeting in Rochester under the auspices of the Western New York-Ontario District, jointly with the Rochester Engineering Society, and Rochester Section of The American Society of Mechanical Engineers. He will deliver his address on the subject "Nine Major Sources of Energy." This paper was an outstanding feature of the Annual Meeting of the American Petroleum Institute, and has aroused much interest. The meeting is to be held at the Hotel Sheraton in Rochester, N. Y.

All members in the district will receive further information by direct mail.

New England—April 14

This meeting, which is to be held in Boston or Cambridge, is to feature the subject of Light Metals and Alloys. A.S.T.M. President Richard L. Templin will give his talk on Aluminum and the plans include titanium and magnesium as subjects for discussion, but further detailed announcement of this meeting will be made.

Air Pollution Meeting in Los Angeles

A MOST interesting and yet perplexing problem which affects many urban and industrial communities was the basis of discussion at the meeting of the A.S.T.M. Southern California District in Los Angeles on November 30, 1948. Dr. Louis C. McCabe, Chief Los Angeles Air Pollution Control District, spoke on "Smog Testing." There were about 110 present at the meeting, the audience being representative of those concerned with this particular problem, and, of course, including many A.S.T.M. members.

Dr. McCabe described the various tests and techniques that have been developed by him and his associates for the purpose of making a sound, scientific study of the smog problem. During his talk there was a demonstration of certain equipment used in the determination of solid particles in the atmosphere and there were also other instruments and apparatus on display.

Dr. McCabe did not bring into his technical address some of the controversial matters that have created much argument and involved political aspects, and at the close, he handled, tactfully, a large number of questions which were addressed to him by the audience.

Affiliated with the Illinois Geological Survey, 1927–1941, except for a short period as Geologist with the Mississippi Coal Corp., he entered the service in 1941 in the Quartermaster General's office and in the Corps of Engineers. He served abroad, becoming a Colonel in

the Corps of Engineers, and was on General Eisenhower's staff as Chief of the Solid Fuels Section of the Section of the United States Forces, European Theatre. Later he was in charge of coal production and distribution in the Ruhr and Saar fields. His work won for him several decorations. Later he was Chief of the Coal Division of the U. S. Bureau of Mines.

In a recent paper presented to the 8th Coal Utilization Conference at the University of Illinois, Dr. McCabe, in discussing air pollution control and some of the problems involved, included descriptions of some of the work at Los Angeles, stressed the need for research and study in this field. He referred to a course at the University of California at Los Angeles covering control of the industrial Smoke, Dust, and Fumes, and concluded thus:

"We have a very great need in this country for a scientific and technical organization devoted to air pollution research, in the broadest sense. It should be adequately financed so as to be free of public and private pressures. In addition to research activities, it would develop standards for the measurement and control of air pollution, whether from the combustion of fuels or the products of atomic fission. It would be a center for gathering and disseminating knowledge on all phases of air contamination. It would thus be useful to the public and to industry."

Active in the planning for this very successful district meeting were the officers of the district: Chairman C. E. Emmons, The Texas Company; and Secretary H. W. Jewell, Pacific Clay Products.

Chicago Area Career Conference

AN INTERESTING educational development in the Chicago area is the Chicago Career Conference held late in December at the Illinois Institute of Technology under the auspices of the Chicago Technical Societies Council, of which A.S.T.M. is a member group. The conference was also sponsored by the Illinois Institute of Technology, and the Chicago *Sun-Times*.

This year about 4000 high school juniors and seniors attended the Conference. Following keynote addresses on each of the three days by leading executives in the Chicago area, there were a large number of smaller counciling sessions. One group was on Engineering and at two of these sessions, the Chairman of the A.S.T.M. Chicago District Program Committee, D. L. Colwell, served as Chairman.

TECHNICAL COMMITTEE NOTES

Radio Tube Cathode Studies to Continue Intensively; Results Briefed

READERS will recall that we have mentioned before in the BULLETIN the extensive work that Committee B-4 on Electrical Heating, Resistance, and Related Alloys has been doing on the emissivity of cathode nickel. All of the manufacturers of radio receiving tubes, as well as the producers of cathodes, the melters and fabricators of nickel alloys, and several government laboratories are represented on the Cathode Section of Subcommittee VIII of Committee B-4 which is making these studies.

The purpose of the Section is to develop and standardize reliable methods for testing cathode base metals. As much remains to be learned about the mechanism of thermionic emission, it follows that the problems of this technical group have been complex. An unusual amount of development work, and even basic research, is necessary.

To form the framework for further progress, the Section has been preparing the following standards, the present status of which is also noted:

1. Methods of Testing Sleeves and Tubing for Radio Tube Cathodes (Issued as Tentative in 1948 under the designation B 128–48 T).
2. Recommended Practices for Running Melt Approval Tests. (Scheduled for early 1949)
3. The Standard Diode Method for Testing Cathode Emission. (Late 1949)
4. Methods for Chemical Analysis of Cathode Nickel Alloys. (Late 1949)
5. Material Specification for Cathode Nickel Alloys. (Mid-1949)

From this point, progress will depend upon the results of research and development projects made available to the Committee for integration into the specification and test method framework.

The primary function of the Section is to develop methods for cathode testing. Research, which is essential due to present inadequate knowledge of cathode behavior, is separate from the Section work. The A.S.T.M. Section will, however, suggest needed development problems and employ available research results in engineering the testing methods.

Some of the problems are being handled by individual companies, and some are conducted under Government contract. Since the problems are admittedly difficult, there is a wholesome interchange of information which helps achieve the common goal—a better understanding of thermionic emission.

The Section has had available for study forty (40) experimental and commercial cathode materials. The experimental melts, with controlled additions to the cathode nickel of carbon, iron, magnesium, silicon, sulfur, titanium, etc., were made up for its use at the special request of the Section. These are being used in various types of diode tubes to determine their effect upon "performance characteristics." Through such a breakdown of the general cathode problem, it is easier to assess the effects of cathode metal changes. Examples of "performance characteristics" are:

1. The rate of activation of a coated cathode.
2. The rate of metallic evaporation from cathode metals.
3. The effect on emission of the surface of the coating.
4. The effect on emission of the bulk of the coating.
5. The effect on emission of the interface between coating and metal sleeve.
6. Influence of metal sleeve upon heater-cathode leakage.
7. Relation between cathode and tube life, and resistance to poisoning.

All of these problems may be affected by different properties of the cathode sleeve or coating. By using several testing methods, these characteristics may be studied. The sum of all the knowledge is then more readily evaluated.

Many years ago Lord Kelvin made a statement that seems particularly appropriate to the objectives of the Section:

"I often say that when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a

meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of Science, whatever the matter may be."

One laboratory has now reported several interesting indications of correlations. First, for a given processing schedule there is a correlation between the speed of cathode emissive activation and the sum of the reducing agents on the base metal—magnesium, silicon, titanium. The total percentages of these three elements in ten experimental alloys studied ranged from 0.060 to 0.230 per cent.

Second, there are signs that the interface color, formed after complete activation between the cathode sleeve and coating, is a function of the silicon and titanium content of the sleeve. As is well known, magnesium alone produces a light interface. It is now believed that magnesium added to the silicon and titanium will also produce a light interface. Further detailed study is necessary.

Third, the metallic deposit formed on the bulb of tubes is magnesium from the cathode sleeve. The amount of deposit is directly related to the amount of magnesium present. This is confirmed by other laboratories, but has been in some question in the past. Of course, there are other sources for evaporated conducting films.

From this type of work, it is expected that solutions will be found to two major problems:

1. What is the "reducing potential" of a given cathode alloy or one of its melts? This should provide a figure of merit for a given lot of material.

2. What cathode alloys are most suitable for the different types of application? This latter is entirely a practical question which will mean much in the economical development and manufacture of ever-improved radio tubes.

The ultimate in process control is essential when a diode or "Measurement Tube" is employed for emission testing. Production of such tubes is consequently slow and expensive, unless widespread use can be made of the results.

It should be stressed that a valuable by-product of the Section work is that the Standard Diode tube can be used equally well as a test method for materials other than cathode sleeves. Thus, new batches of coating materials (heater, cathode, mica, or grid), or plates (especially carbonized metals), grid wire, and getters can be successfully compared with a standard for certain performance characteristics. The original Standard Diode may now be considered as a new tool for incoming material inspection departments. It is not a particularly difficult task to correlate the Measurement Tube results with production factory performance, and thereby establish acceptance limits.

Probably one of the most worthwhile achievements of the Cathode Section has been to show the relative importance of each of the many phases of tube manufacture upon the emission of the cathode. Such lessons translated onto the production floor can readily repay (many times) the time and money expended by the participating companies.

Important Announcements on Portland Cement Testing

Safety Precautions to Be Observed when Making Autoclave Tests of Portland Cement

SOME recent incidents have prompted A.S.T.M. Committee C-1 on Cement to express the desire that publicity be given to the following safety precautions that should be observed when operating autoclaves under the A.S.T.M. Method of Test for Autoclave Expansion of Portland Cement (C 151):

1. The pressure gage should have a maximum capacity of from ½ to 2 times the working pressure—in other words, 450 to 600 psi. This is important because with too small capacity there is but little length of arc in which the gage hand may indicate pressures above the specified maximum working pressure. The operator must be sure that the gage hand has not passed the maximum graduation on the scale.

2. It is well to have the pressure gage tested, but in any event a thermometer should always be used together with the pressure gage, so as to provide a means of detecting any failure of the pressure gage to operate properly, and also to indicate any unusual condition such as that resulting from loss of water from the autoclave during the test.

3. The automatic control should be maintained in proper working order at all times.

4. The safety valve should be set so as to relieve the pressure at about 6 to 10 per cent above the maximum of 305 psi. specified in C 151, that is, at about 330 psi. The safety valve should be tested at least twice a year, either with a gage-testing device or by adjusting the automatic controls so as to allow the autoclave to reach a pressure of about 330 psi., at which pressure the safety valve should either open or should be adjusted to open. The safety valve discharge should be directed away from the operator.

Unexpected combinations of conditions may really occur. For example, in a recent case the automatic control had failed, the safety valve had become stuck, and the gage hand, which at first glance appeared to be at about zero, had really passed the maximum graduation and had come to stop on the wrong side of the pin. This condition of the gage was finally detected and the pressure, then of an unknown magnitude, was released before failure could occur in the apparatus. One autoclave recently exploded, the top passing through the ceiling of the laboratory.

5. Heavy leather work gloves should be worn to prevent burning of the hands when removing the top of the autoclave at the end of the test. The vent valve should be directed away from the operator. When removing the autoclave lid, the lid should be so tilted that any steam escaping from beneath the lid may be discharged away from the operator. Care should be taken to avoid scalding by any liquid that may have been used in the autoclave well.

6. It should be remembered that for many of the autoclave pressure gages now in use the return of the gage hand to the initial rest or starting point does not necessarily indicate zero pressure within the autoclave—there may then be a pressure as great as 10 psi. or more.

7. A few drops of kerosene placed in the vent valve about once a week will aid in keeping the needle clean and in good working condition.

Improved Flow Table Design Developed by Cement Committee

COMMITTEE C-1 on Cement has given considerable study over a period of time to the design of an improved flow table as used in the Standard Method of Test for Flow of Portland Cement Concrete by Use of the Flow Table (C 124). The endeavor has been to specify a table that would give concordant results among laboratories, which have been lacking in the past, and at the same time permit the utilization of the vast majority of the existing flow tables. This design is being coordinated

with other interested A.S.T.M. committees and will also be used in Federal Specifications. The revised description of the table with the necessary illustrations is now being balloted on in Committee C-1, and it is hoped that approval by other technical committees concerned and the ensuing O.K. by the Society can be announced in a few weeks. The March BULLETIN will give some further details.

Gaseous Fuels

COMMITTEE D-3 on Gaseous Fuels at a meeting in Atlantic City on October 3, 1948, reviewed the status of its program on the development of methods pertaining to the analysis and testing of gaseous fuels. The committee has under review a revised method for sampling of natural gas. It also has in preparation separate methods for sampling manufactured gas and for liquefied petroleum gases.

Methods for the measurement of gaseous fuel samples have been completed and, it is hoped, will be approved by vote of the committee in time for their presentation to the Society as tentative at the Annual Meeting in June.

The Method of Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter (D 900 – 48) was recently adopted as standard. In connection with this method the committee is investigating the Cutler-Hammer calorimeter. Some preliminary work has been done in the Gas Chemistry Section of the National Bureau of Standards. A sample of methane has been obtained which is of relatively high purity but not sufficiently pure for the purpose. Apparatus for further purification of the sample has been designed and constructed.

Also under development are methods of analysis for sulfur in gaseous fuels by combustion with purified air. These methods will be applicable to manufactured, natural, or mixed fuel and illuminating gases. A subcommittee is collecting available data on the referee test for total sulfur together with any modifications which appear to be improvements. It is also doing the same thing with respect to the total sulfur method. After all of these data are collected, attempts will be made to evaluate them and reach a decision as to which method is preferable for publication as an A.S.T.M. tentative.

A method for analysis of natural gas by the mass spectrometer is being further revised by another subcommittee. This method is expected to be completed in time for presentation as tentative at the June meeting. A proposed tentative method for the analysis of natural gas by chemical methods is nearly completed.

Data from the cooperative analysis of a standard sample of the carbureted water gas type by the mass spectrometer are now ready for presentation in the form of a series of frequency distribution plots. The data show the superiority of the mass spectrometer with respect to the analysis of the hydrocarbon fraction of this sample. However, chemical methods for the determination of hydrogen and carbon monoxide yielded more consistent results. The direction for improvement of the spectrometric method for these two gases has already been indicated, following the demonstration of the need for greater accuracy; but it is not yet certain whether or not the ultimate standard will combine the chemical and spectrometric approaches.

One of the most difficult problems that has been under study by this committee has been the determination of specific gravity of gaseous fuels. An extensive study made by the Bureau of Standards on "Tests of Instruments for the Determination, Indication, or Recording of the Specific Gravities of Gases" has been published as N.B.S. Miscellaneous Publication M177. Based on the information and data obtained in this study the committee has in preparation methods for determining specific gravity which will cover the use of two instruments found to give the most reproducible results. Provision will also be

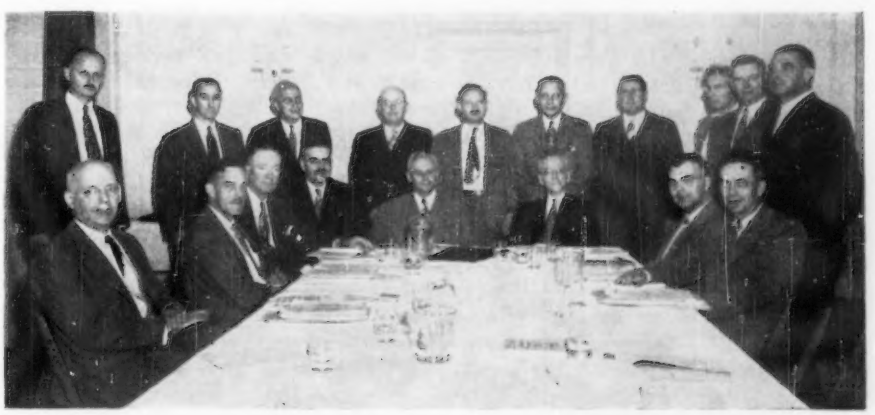
Recommended Editorial Revisions in Tolerances in Dimensions of the Blaine Air-Permeability Apparatus for Determining the Fineness of Portland Cement

CERTAIN *editorial* changes, effective immediately, in the tolerances in dimensions of the air-permeability apparatus specified in the A.S.T.M. Tentative Method of Test for Fineness of Portland Cement by Air-Permeability Apparatus (C 204 T) were recommended and accepted at the last meeting of Committee C-1 on Cement.

The revisions are as follows:

1. Change cell height from 5.0 ± 0.5 cm to 5.0 ± 1.5 cm.
2. Change required number of holes in disk from 30 ± 5 to 35 ± 5.
3. Change tolerance of length of manometer from lowest mark to top of side arm from 12.5 to 14.0 cm. to 12.5 to 14.5 cm.
4. Change tolerance of length of manometer from lowest mark to bottom of U tube from 12.5 to 14 cm. to 12.5 to 16.0 cm.

These changes in dimensions of the air-permeability apparatus will not affect the results of tests, will not exclude any equipment manufactured to meet the present tolerances, and will get the instrument as specified in line with manufacturing practice.



Photograph at the Meeting of A.S.T.M. Committee D-3 on Gaseous Fuels in Atlantic City. Seated at table from l. to r.: K. E. Baird, Philadelphia Coke Co.; R. L. Dodge, E. I. du Pont de Nemours and Co., Inc.; R. M. Conner, American Gas Association Test Laboratories; A. W. Gauger, The Pennsylvania State College, Chairman of Committee D-3; E. F. Schmidt, Lone Star Gas Co., Vice-Chairman of Committee D-3; K. R. Knapp, American Gas Assn. Testing Laboratories, Secretary of Committee D-3; E. O. Mattocks, Phillips Petroleum Co.; and E. X. Schmidt, Cutler-Hammer, Inc. Standing from l. to r. are F. A. Hough, Southern Counties Gas Co.; F. E. Vanadveer, East Ohio Gas Co.; E. R. Weaver, Bureau of Standards; J. G. Sweeney, Brooklyn Union Gas Co.; Benjamin Miller, Inst. of Gas Tech.; S. S. Tomkins, Consolidated Edison Co. of N. Y.; P. J. Smith, A.S.T.M.; H. S. Bean, National Bureau of Standards; A. F. Bensen, American Meter Co.; and J. E. Overbeck, Ohio Fuel Gas Co.

made for checking results obtained by use of any specific gravity instruments against similar findings obtained by application of the weighing method. The specific gravity test provides data used in computing the flow in cubic feet of gaseous fuels (including liquefied petroleum gases, in gaseous state at normal temperatures, and pressures) through orifice meters. It is employed for laboratory, control, or referee purposes as well. Occasionally the densities of fuel gases vary from day to day. Under such circumstances it is necessary either to make frequent specific gravity determinations or to obtain a continuous record, or both, of such variations.

Three Papers in Insulating Oil Symposium, March

THE third session of a series of Symposia on Electrical Insulating Oil, sponsored by Subcommittee IV on Liquid Insulation, of A.S.T.M. Committee D-9 on Electrical Insulating Materials, will be held on March 23, at the Shoreham Hotel, Washington, D. C., in conjunction with the spring meeting of Committee D-9.

Both producers and consumers of electrical insulating oils are especially interested in developing means of improving the life of insulating oil in electrical apparatus and the development of improved test procedures that will allow accurate appraisal of a new oil or an oil in service with reference to its continued serviceability. The plan was developed by Subcommittee IV in 1946 to hold an insulating oil symposium of several sessions in sequence at appropriate intervals along with scheduled meetings of Committee D-9 and its subcommittees.

The first program was presented October 16, 1946, in Atlantic City. The discussions on this program were directed chiefly to the Steam Emulsion Test as an index of transformer oil stability and the Interfacial Tension Test and its significance in appraising performance of an insulating oil. Also the application of statistical analysis was reviewed for the handling of available data on dielectric strength of oil in conjunction with a study preparatory to revising the standard method for this test. The papers presented at this first session were printed in the issues of the ASTM BULLETIN for May and December, 1947.

The second session of the symposia was a part of the program of the A.S.T.M. Annual Meeting in Atlantic City in June, 1947. The attendance at this symposium again indicated the wide interest in the subjects of inhibited insulating oil and the meaning of power factor testing of oil, which were the chief subjects discussed in the four papers presented. All of these papers and complete discussion were subsequently published in the ASTM BULLETIN of December, 1947.

The third Symposium will include three papers of particular value with titles essentially as follows:

One System of Laboratory Testing, to Appraise Serviceability of Oils in Transformers, by R. G. Call, American Gas and Electric Service Co.
Performance Characteristics of Askarel, by F. M. Clark, General Electric Co.
Performance of Inhibited Insulating Oils, by G. H. von Fuchs, Consulting Chemical Engineer.

All of these subjects are currently very pertinent to consumers' and manufacturers' interests and a wide attendance is anticipated at this session of the symposia.

Textiles on the International Front (continued)

General Proceedings (from page 19)

with some of those who were to be part of the British delegation and to have a preliminary informal exchange of views.

The ISO meeting was opened on Monday, June 7, at the Palace Hotel, Buxton, Derbyshire. Upon nomination by the U. S., Sir William Larke, Vice-President of the British Standards Institution, was elected as the Conference Chairman. Registration data showed that 13 countries were represented by 93 delegates, of whom 49 were from the United Kingdom. The countries represented were: Australia, Belgium, Czechoslovakia, Finland, France, India, Netherlands, New Zealand, Sweden, Switzerland, United Kingdom, United States of America, USSR.

With the exception of two afternoons when visits were scheduled, plenary sessions of the delegates were held each morning and afternoon. Proposals and papers dealing with the topic, often prepared and distributed in advance, were presented by any country which wished to be heard. English and French were the languages used, and translation of oral presentations from one language to the other was immediately given when called for by any country. When discussion was concluded the chairman announced that a subcommittee would be appointed to consider the presentations and to report back to the full body of delegates at the earliest opportunity. Each country was then pooled to determine whether it wished to be represented on the subcommittee and by whom. Representation was not limited to one delegate.

The chairman of the subcommittee, always a member of the British delgation, was then announced, together with the time and place of meeting. The work in the subcommittee proceeded in much the same manner as in the meetings of the subcommittees and sections of A.S.T.M. Committee D-13, namely, by across-the-table presentations and discussions of the various subtopics into which the subject was divided. The objective was to determine what consensus of agreement could be reached, and to decide upon what recommendations should be reported to the next plenary session for action. More than one meeting of a subcommittee was required on several projects.

By such procedure, the Conference arrived at a series of conclusions or statements which are discussed in later sections of this report.

The Committee selected subjects for initial consideration and for the purpose of gaining experience for the development of the program, as follows:

(*a*) Cloth strength testing.
(*b*) Humidity and temperature, and conditioning.
(*c*) Sampling and statistical methods of analysis.
(*d*) Analysis of fiber mixtures.
(*e*) Commercial weights and moisture regains.
(*f*) Definitions and nomenclature.
(*g*) Color fastness tests, with particular reference to light, washing, and perspiration.
(*h*) Shrinkage of fabrics in washing.

(*i*) Restriction of the variety of cloth widths.

(*j*) Systematic restriction of variety of yarn counts.

(*k*) Cordage, ropes, etc.

(*l*) Methods of testing all types of yarn.

(*m*) Methods of fiber testing with special reference to man-made fibers.

(*n*) Determination of cloth, width, length, weight, and structure.

Of the foregoing subjects, items (*a*), (*b*), (*c*), (*d*), (*e*), (*f*), and (*n*) are to be dealt with by the Secretariat of Technical Committee 38. The remaining subjects are to be dealt with by subcommittees. Of these the United States expressed an interest in (*g*), (*h*), (*l*), and (*m*).

Tension Testing of Fabrics

Contributed by H. J. Ball[2]

ON THE subject of the tension testing of fabrics, the Conference adopted the following recommendations with one abstaining vote, namely, that of France.

1. That it would be desirable to agree upon a basis for the tension testing of textiles so that test results obtained in various laboratories and in various countries could be used for purpose of comparison.
2. That as far as possible the tension test should be a measure of resistance to tension as distinct from resistance to tearing or distortion.
3. That the most suitable test for this purpose is the strip test.
4. That the detailed requirements for carrying out the test should be specified in both the metric and inch-lb. systems and that the two sets of requirements should be approximately equivalent.
5. That the requirements for the test strips should be as follows:
   (*a*) Width: 5 cm. (or 2 in.).
   (*b*) Distance between jaws: 20 cm. (or 8 in.).

   NOTE.—It was suggested that consideration might be given to the use of an interim measure of a one-inch strip with a distance of 3 in. between the jaws.
   (*c*) Width of fringe, if any: 0 to 5 cm. (or ¼ in.), or 15 threads, whichever is the greater, unless otherwise agreed between the interested parties.
   (*d*) Initial tension: The initial tension should be applied uniformly across the width of a strip without causing distortion or stretch. The initial tension should be as follows:
   (i) 200 g. for cloths weighing less than 150 g./sq. m.
   (ii) 500 g. for cloths weighing 150 to 500, g./sq. m. inclusive.
   (iii) 1 kg. for cloths weighing over 500 g./sq. m. or the equivalents in inch-lb. units.
6. That preference should be given to constant-rate-of-loading machines where these machines are available.
7. That the method of carrying out the test on constant-rate-of-loading machines should be as follows:
   (*a*) Duration of test. The time taken to break the specimen should be 60 ± 10 sec.
   (*b*) Take-up. The take-up of the elongation should preferably be automatic, but other methods may be used by agreement between the interested parties.
8. That the method of carrying out the test on constant-rate-of-traverse machines should be as follows:
   (*a*) Constant-rate-of-traverse machines of the pendulum or spring types should be arranged with speed changing mechanism and operated so as to break the specimen in a standard time.

   NOTE.—There is some difference of opinion regarding the appropriate standard time but a majority of the subcommittee favors 60 ± 10 sec.
   (*b*) The type of machine used should be specified in the report of the test.

   NOTE.—The above recommendations are not intended to preclude the consideration at some future time of new types of testing machines.

Conditioning of Test Specimens

Contributed by G. S. Buck[2]

THE sensitivity of textile materials to the ambient atmosphere, especially to the moisture content of the air, is well known. In order that other testing methods, when standardized, might provide agreement in the various countries, it was first necessary to insure that the tests would be carried out under uniform atmospheric conditions.

The American delegation went to the ISO conferences with a rather clear understanding of the wishes of the textile industry in this country on the subject of standard testing atmosphere. The textile industry in this country overwhelmingly favored testing at a relative humidity at 65 per cent. The question of temperature showed a more divided opinion in the textile industry, but there was no evidence of strong inclination to change from 70 F. Thus it was highly desirable that the American delegation to the Buxton conferences secure international recognition of our long-established conditions of 70 F. and 65 per cent relative humidity if possible.

Following the ceremonies which opened the conference, Dr. A. B. D. Cassie of the U. K. delegation introduced the subject and referred briefly to definitions and figures which might be discussed. Although the British practice had been to use 70 F. and 65 per cent relative humidity, their new handbook had made a concession to continental preferences and recommended 68 F. plus 9 F. minus 4 F., together with 65 per cent relative humidity plus or minus 2 per cent.

Mr. Bharat Ram of India submitted a seven-page document in which the peculiar climatic conditions of India were outlined, and which suggested the establishment of two atmospheric standards, one of which would be based on 80 F. and 80 per cent relative humidity.

The Czechoslovakian delegation had submitted a document recommending 65 per cent plus or minus 2 per cent for relative humidity and 20 C. plus 5 minus 2 C. for temperature.

Dr. Conrad of the U. S. A. delegation submitted a document which outlined the American preferences for 65 per cent relative humidity plus or minus 2 per cent and 70 F. plus or minus 2 F.

A committee was selected to carry on further discussions designed to make possible an agreement which would resolve the differences in conditioning practices. Originally Belgium, France, India, the Netherlands, Sweden and Finland, Switzerland, the U. K. and the U. S. were represented on this committee. In later discussions, New Zealand, Czechoslovakia, and the U.S.S.R. also joined the committee.

The committee first agreed upon definitions for humidity, absolute humidity, relative humidity, and dew point which were substantially the same as those used both in U. S. and U. K. The question of standard atmosphere was next considered and India yielded and unaminous agreement had been reached on 65 per cent relative humidity. The relatively less important question

[2] National Cotton Council, Memphis 1, Tenn.

of temperature seemed to be the point upon which it was most difficult to reach agreement. All continental European nations favored 20 C. (68 F.), and since the U. K. had already made a concession to that temperature in its new standards, the U. S. and India alone preferred temperatures other than 68 F. India's unusual climate was recognized in a supplementary temperature of 80 F. which was allowed for testing within such a country as India or between a tropical country and another country when 80 F. was mutually agreeable.

Since the United States' viewpoint prevented a unanimous agreement on temperature, the atmosphere for testing was considered in the hope that tolerances might provide an answer to the differences of opinion on temperature. A number of European countries preferred rather wide tolerances in temperature, specifying plus 9 F. and minus 4 F., thus permitting a temperature range of 64 F. to 77 F. After some discussion the American view that the tolerances should be kept as narrow as possible was accepted, and the temperature tolerance was established as plus or minus 2 C. The final recommendations of the committee on standard atmosphere were (*a*) relative humidity 65 per cent, (*b*) temperature 20 C. (68 F.), and (*c*) supplementary temperature of 27 C. (80.6 F.). The atmosphere for testing allowed a tolerance of plus or minus 2 per cent from the standard relative humidity and plus or minus 2 F. from the standard temperature.

Unanimous agreement by all participating countries was achieved on the conditioning standard which had been considered by the committee, with the one exception that the U. S. preferred 70 F. to 68 F. The American delegation gave careful thought to this problem of disagreement on temperature, realizing that the 68 F. standard was an aiming point, and that for all practical purposes the tolerance of plus or minus 2 C. placed our testing conditions within the international range. In the interest of harmony and because our delegation wished to show its spirit of cooperation, the American objections to 68 F. were withdrawn.

It still remains for the recommendations made in Buxton to be ratified by the standardizing bodies of the member countries. There are also a number of items related to the conditioning of test specimens which are yet to be considered by Technical Committee 38. These include moisture regain in textiles, the rate of moisture absorption by textiles and time to condition, the need to approach standard conditions from the low humidity side, and the effect of finishing on regain. The agreements that were reached, however, are fundamental to standard conditioning practices and should provide a sound basis for further standardization of the more detailed subjects.

A Universal Yarn Numbering System

Contributed by A. G. Scroggie[4]

As a background for the discussion on yarn numbering I would call attention to the multiplicity of systems which are currently used. In almost every case a different system is used for each of the naturally occurring fibers, and in a number of cases several systems are used for the same fiber even in a given country. The denier system is used for most man-made products. This situation results in considerable confusion and has been materially aggravated in recent years by the introduction of man-made yarns into many mills, which until recently handled only a single natural fiber. Everyone who has considered this situation agrees that if a universal yarn numbering system could be adopted it would be a worth-while accomplishment.

In an attempt to reduce this confusion, the American Society for Testing Materials, in 1943, proposed a universal yarn numbering system which was direct, meaning that the yarn numbers increased with the size of the yarn. It was decimalized to make calculations easy and was based on metric units. This was designated as the Grex system and the grex unit was defined as the weight in grams per 10,000 meters of yarn. In this system, grex yarn numbers are approximately 1.1 times the well-known denier units. It was subsequently approved as a Recommended Practice by the A.S.T.M. Committee D-13 on Textile Materials.

In 1945 the British Definitions Committee called a conference to study this subject. They concluded that a direct, decimalized system using metric units was desirable, but preferred a unit based on grams per 1000 meters and this proposal has been designated as the gK system.

At Buxton all countries represented at the International Standards Organization Conference agreed that any universal system should be direct, decimalized, and based on metric units, and the discussions which were held were devoted to a consideration of the respective merits of grex and gK units.

The chief argument advanced by the British delegation for gK units is that the numbers of normal yarns would be expressed with only two digits. Tenacities would be roughly ten times the g. per denier value and carry one less decimal than at present and would also be directly related to breaking length, a term frequently used in Europe. For those who are not familiar with this term I might say that a yarn having a tenacity of 2.2 g. per denier would be reported as 2.0 g. per grex or 20 g. per gK unit. All three expressions are equivalent to a breaking length of 20 kilometers and mean that 20 kilometers of the yarn would break of its own weight if suspended by one end.

On behalf of the grex system we pointed out that it has been published for two or three years now as an A.S.T.M. Recommended Practice and had been used in a number of technical communications. We also pointed out that experience with the denier system indicated two digit numbers were not particularly desirable and that, in fact, all yarn producers who attempt to control their product within a small percentage variation must necessarily use three significant figures for average values and it is desirable to use three figures without decimal fractions in order to save time and avoid possible confusion. An added argument in favor of the grex system is that all natural fibers have a grex yarn number of one or more, and grex numbers from 1 to 9000 cover practically all natural and man-made fibers, filaments, yarns, and cords with a single scale. The gK system, on the other hand, proposes to use a separate set of units or scale for fibers and filaments, but here they favor three digit numbers and this, it is believed, will result in further confusion since fibers and cords will use some of the same numbers but in different scales. For instance 1.5 denier staple and 1500 denier cord will both be No. 165.

Following a general discussion of the merit of the two systems, the United States and Belgium voted in favor of the grex system, the other continental countries except Switzerland voted in favor of the gK unit. The British delegation abstained from voting because several of their members were in favor of the grex system even though the gK system was officially proposed by the British Textile Institute.

The fact that all delegations agreed

[4] E. I. du Pont de Nemours & Co., Inc., Rayon Department, Richmond, Va.

that a universal system should be direct, decimalized, and based on metric units is a definite accomplishment. The committee recommended use of both grex or gK units alongside existing systems for the time being.

If in this country we feel a preference for the grex system, it would appear that we should start to use it and the way in this case is for the consumers of yarn to specify grex yarn numbers in their orders since in the long run producers will never dictate to their customers. The Textile Institute is actively advertising the gK system and has printed small booklets discussing its merits. The difference in units which we are discussing is not serious and it is possible, though undesirable, that both systems could be used simultaneously in the future. It would be comparable with one group reporting the length of a sample in millimeters while a second group used centimeters. As long as the proper labels are applied, results can readily be converted by multiplying or dividing by ten. This of course applies both to the yarn numbers and any derived values such as tenacity.

The committee also discussed the desirability of coining terms to cover the concept of size of yarn and yarn numbers. A number of people have objected to the term grex. One proposal was the term "mel" for the unit and "melidity" for the property. The adjectival form would be "melid."

The Definition of Rayon

Contributed by A. G. Scroggie[4]

THE U. S. Delegation opened the discussion by reviewing the history of this word and the causes of the current confusion. The term rayon was first proposed in the U. S. in 1924 and was officially defined in 1926 by the A.S.T.M. At that time rayon was restricted to cellulose-base type fibers. In this country this interpretation was confirmed by the Federal Tariff Commission in 1930 and by the promulgation of the Fair Trade Practice rules for the Rayon Industry in 1937. The term rayon was not used extensively in Britain, however, until recently, and viscose and acetate rayons have been referred to as artificial silk in official documents in the United Kingdom.

A few years ago the Definitions Committee of the British Textile Institute proposed that the word rayon be used as a generic term for all man-made fibers. The A.S.T.M. protested against this proposal, pointing out the status of the word in this country and several communications were exchanged regarding the historical position of the term. The British Textile Institute, advised by the British Rayon Federation, took the position that, at the date of its introduction, the word rayon was coined to cover all man-made fibers and that they were merely perpetuating this idea in defining it in these terms at this time. In the general discussion at the International Standards Organization meeting, however, other textile interests, including representatives of the British Nylon Spinners, British Fiber Glass, and the Imperial Chemical Industries who are manufacturing a protein base fiber, all objected to this term. The American Delegation also read a protest which had been received from the British Retail Trade.

None of the representatives from other countries supported the British position and after hearing the various speakers, the committee adopted a resolution in which it was agreed that the use of the word rayon as a generic term for all man-made fibers was undesirable.

In a subcommittee meeting following the general discussion, the delegates decided that it would be desirable to have a family term for all man-made fibers which could be used by writers for statistical and other purposes. Some discussion was given to this matter but no decision was reached. The delegates felt that the term man-made was not satisfactory and all countries are invited to submit their suggestions. The French delegation wanted a special word for all truly synthetic fibers, and proposed the word "fibranne" as a generic term for staple rayon fiber.

We reported the dissatisfaction which had been felt in various branches of the Textile Trade in the United States regarding the use of the one word rayon for products which are as dissimilar as regenerated cellulose and cellulose acetate. We reported that a substantial majority of the textile industry, as exemplified by the membership of the A.S.T.M. Textile Committee, had agreed that it would be desirable to distinguish these products and to coin a new term for cellulose acetate and similar cellulose ester type yarns. We also advised that the word "estron" was receiving favorable consideration in this connection.

This specific problem has not caused much difficulty on the continent or in England and had not reached the stage where the trade felt something needed to be done about it. The Conference decided not to take any action on this particular phase of the definition of rayon at the 1948 meeting. After they have had time to consider it, we may find that the American position will be accepted by other countries.

Observations on Textile Standardization in Europe[1]

By Wm. D. Appel[2]

THE Buxton meeting of Technical Committee 38 on Textiles, International Organization for Standardization, provided an opportunity for members of the U. S. delegation to meet leaders in textile standardization in other countries. In addition, some of us took the occasion to visit European testing and research laboratories.

Textile research and standardization in the United Kindgom is carried out by the research associations of the several branches of the industry, by the universities, and by the technical societies. The "Shirley Institute" of the Cotton Industry Research Association in Manchester, whose fine work is well known in the United States, deals not only with all phases of cotton, but it has sections on rayon and silk. The Institute has a staff of 400 and expends about one million dollars annually. The Institute is very well equipped but is in urgent need of additional personnel and new buildings. The latter have been approved and work on them is to start soon. The Director, Dr. F. C. Toy, is the current President of the Institute of Physics, an indication of the scientific caliber of the work of the Institute.

The Wool Industries Research Association at Leeds, with a staff of some 120, is housed in several converted mansions. Two new buildings are under construction and additional personnel is needed. Work in progress includes

[1] Record of a talk at the Papers Session of Committee D-13 on Textile Materials, American Society for Testing Materials, on October 14, 1948, in Washington, D. C. The talk was illustrated with Kodachrome slides of textile research institutions and personnel in England, Ireland, Holland, Sweden, and Norway.

[2] Chief, Textiles Section, National Bureau of Standards, Washington, D. C.

development of referee methods for measurement of the fineness and length of wool, measurement of yarn irregularity, adsorption of liquids and swelling of keratin and other fibrous materials, long-range stress and relaxation studies of wool. Mechanical and photoelectric integrating evenness testers have been built and are being studied. Mr. B. H. Wilsdon, Director of Research, is chairman of the Technical Committee of the International Wool Textile Organization.

The Linen Industry Research Association at Lambeg near Belfast, North Ireland, Dr. A. J. Turner, Director, has a staff of over 100. It serves the Irish and Scottish linen industries in testing, research, and consultation on scientific and technological matters. The laboratories are in a converted mansion and some modern one-story buildings, including new buildings, dedicated in July, which expanded the facilities one third. A well-designed system of retting tanks and machinery for extracting the fiber, preparing, spinning, dyeing, finishing, and weaving it are available.

Leeds University is the home of much important research relating to textiles, especially wool and dyes. Dr. J. B. Speakman, Head of the Department of Textile Industries; Dr. W. T. Astbury, Head of the Physics Department; and Dr. Wm. Bradley, who has succeeded the late Dr. F. M. Rowe as Head of the Department of Color Chemistry and Dyeing, were absent at the time of the visit. Dr. A. B. Meggy showed the laboratories and told about the work in progress on the structure of wool. Leeds has received a grant from the International Wool Secretariat with which the work is being expanded as rapidly as man power and space can be provided.

Prof. H. J. Ball accompanied the writer to the College of Technology, Manchester. Dr. F. Scholefield and Mr. W. E. Morton, who head, respectively, the Department of Textile Chemistry and Department of Textile Technology, were most cordial in showing their testing and research facilities. With several members of their staffs, they discussed work in progress on deterioration of cotton at fiber-water-air interfaces, creep-relaxation studies, and factors affecting production, including card speeds and air currents. The position of individual fibers in sliver, roving, and yarn at different stages of processing was being investigated with the aid of a blend of 0.1 per cent dyed fibers with undyed. The sliver is viewed in a solvent of suitable refractive index to make the undyed fibers invisible and the position of the dyed fibers is plotted in three dimensions.

Men from these and other associations and colleges, and from industrial laboratories, for example those of the Imperial Chemical Industries, Ltd., and the Calico Printers Association, Ltd., which were visited, work together in the committees of the technical societies on test methods and standards. The Society of Dyers and Colourists, like the American Association of Textile Chemists and Colorists in this country, has taken the lead in developing methods for testing color fastness. In 1938, the Textile Institute initiated the preparation of standard methods of test, especially methods dealing with physical properties, moisture relations, and methods of identification. A "Unification of Test Methods Committee" was formed for this work, and in 1942 a "Terms and Definitions Committee" was appointed. A "British Standard" handbook of "Methods for Testing Textile" was in course of publication at the time of the Buxton Conference. It includes a selection of methods used by the research associations and methods for rayon prepared by the Rayon Industry Committee of the British Standards Institution. It is the British equivalent of the Committee D-13 book of Textile Standards.

The British textile research and standardizing organizations, unlike those in the United States, are jointly financed by the government and the industry. This is also true in the Netherlands and Sweden. In each of these two countries, however, a single organization serves all branches of the textile industry.

The Fiber Research Institute at Delft is well equipped with textile testing and research tools, including, for example, the various testing devices developed by Dr. E. C. Dreby for Committee D-13 and by Dr. H. F. Schiefer at our National Bureau of Standards. Equipment for measurement of yarn irregularity by electrical and optical methods is being developed. The spectrophotometric method is being applied to the problem of determining kind and amount of dyes required to match colors. Practical studies, for example, of mildew-proofing agents, and theoretical studies, for example, examination of wool with the electron microscope, are undertaken. The Laundry Institute, in the same building with the Fiber Institute, is doing interesting work on evaluation of detergent efficiency with standard soiled cloth. Dr. J. R. H. van Nouhuys, Director of the Fiber Institute, was a member of the Netherlands delegation at the Buxton Conference.

The Swedish Institute for Textile Research, at Gothenburg, has a fine new building. In addition to the usual minor equipment, it has a complete pilot plant for wet processing, dyeing, and finishing built of monel metal half the size of regular plant equipment, and an ultracentrifuge, X-ray diffraction equipment, electron microscope, and supersonic equipment. Research in progress includes study of the frictional properties of fibers, degradation of wool, bending modulus, and water repellency. The Director, Dr. Nils Gralén, represented Sweden at Buxton. He is a member of the Swedish textile standardization committee which, in cooperation with similar committees in Norway and Denmark, is writing standard textile test methods for use in all three countries.

The Norwegian textile standardization committee, Mr. Christian Conradi, Chairman, held a special meeting during the visit to Oslo, for a discussion of details of some of the test methods used in the United States. Dr. Bailli Nilssen, the Secretary of the Committee, is installing a textile laboratory in the new School of Chemistry and Physics of the University of Blinderen, Oslo, which will be used for the work of the committee and for testing for the industry. The committee hopes to complete its set of standards in two years.

Although the textile test methods used in Europe are being brought together under one cover for the first time, methods comparable to the D-13 methods have been in use for years. The research and testing personnel are thoroughly familiar with the fundamental properties of textiles, the latest developments in electronic equipment, and with statistical procedures in research and standardization.

A.S.T.M. textile test methods are receiving careful scrutiny by all of the European groups mentioned. Many of the methods differ from the European methods only in detail. Others, for example the tests for breaking strength of fabrics, differ materially from the European methods. In order to carry out its part in the program adopted at Buxton, Committee D-13 will have to compare European methods, and the reasons for them, with its own. This will lead to closer contacts with European research and testing laboratories. The exchange of knowledge and experience will undoubtedly result in improved test methods. It is not too much to hope that by working together the countries represented on the ISO committee will arrive at generally recognized standards for the testing of textiles in international trade.

A Report on the International Wool Conference in Amsterdam, Holland[1]

By J. I. HARDY[2]

THE Wool Conferences in Amsterdam took place at the Sectis Confectis (some government building), and also at l'Hotel Krasnapolsky. There were seventeen countries represented and about one hundred and sixty in attendance.

This conference devoted much of its time to discussions of various methods of wool and yarn technology during the first three days at the Sectis Confectis conference room, followed by two days of speeches and public reports at l'Hotel Krasnopolsky.

Dr. Palmer, from the laboratory of the British Research Association, discussed details of the proposed international tests on the determination of wool fineness by four different methods: (1) gravimetric, (2) gravimetric as modified by Maillard, (3) gravimetric as modified by Rochrich, and the projection method. The British Wool Research Organization at Leeds (Torridon), England, has prepared twenty sets of samples for tests, if possible, in twenty different laboratories. Arrangements have been made for tests in Belgium, Canada, Czechoslovskia, Holland, Italy, two in France, and one in the United States. I was requested to find out if two more of these sets might be tested in the United States, and I should like to take this opportunity to make this request known. There are many countries overseas that are struggling with many of the same problems in testing and standardization as we are. They are eager for our cooperation in improving their methods. Such a program has a much broader relationship than helping to get a new and better test method. It means a better over-all understanding.

A full and open discussion was entered into by the entire committee upon many details relating to these four methods for measuring fineness.

A paper by Mr. S. L. Anderson of the Wool Industries Association on the "Combed Tuft Method of Fiber Length Measurement" was reviewed. In this method a length of sliver is clamped between two parallel bars and the fibers not gripped are combed out and discarded. The two protruding combed tufts are cut and weighed as well as the clamped length of sliver. The fiber length is then determined by a formula.

Much attention was given to yarn irregularity. A committee is setting up a new international experiment on yarn testing at Dr. Palmer's invitation. The use of the "electric eye" has been so developed that a piece of yarn can be automatically measured for its irregularities at very frequent intervals. This was demonstrated at the Vesel Institute at Delft, Holland.

Another paper of interest in connection with fiber measurement was "The Effect of Moisture on Wool Fineness Measurement," by Anderson and Palmer. In this discussion Palmer pointed out that some mediums give more accurate results than others, owing, perhaps, to easier focusing with the microscope.

There was also a paper upon "The Chemical Tests for the Estimation of Alkali Damage to Wool," by S. Blackburn, of the Wool Industries Research Association. This paper offers a new approach to the detection of damaged wool.

The program which followed for the last two days of the session was on the work of the International Wool Secretariat and that of the International Wool Textile Organization. There were discussions on wool by leading world figures well versed on wool in its entire economic structure. Before going to England I knew there was an I.W.S. (International Wool Secretariat) and an I.W.T.O. (International Wool Textile Organization) but I now have heard their leading men, speak and realize the greatness of these organizations and what such backing means to a wool industry. In the words of Dr. Booth of the I.W.S.: "We are concerned with ensuring that growers can, over a long-range period ahead, readily sell all the wool they produce, and at remunerative prices."

[1] Presented at the meeting of A.S.T.M. Committee D-13 on Textile Materials, October 14, 1948, Washington, D. C.

[2] United States Department of Agriculture, Bureau of Animal Industry, Washington, D. C.

Second International Technical Congress

AN INTERNATIONAL Technical Congress is to be held at Cairo, Egypt, March 20–26, 1949. This Congress has been endorsed by the Engineers Joint Council which wishes to encourage the submission of technical papers by American Engineers. Any A.S.T.M. members and others who would be interested in submitting papers are requested to contact S. L. Tyler, Secretary of the Engineers Joint Council, 29 West 39th St., New York 18, N. Y. (The Engineers Joint Council is a Joint Committee of the four Founders' Societies plus the Institute of Chemical Engineers, the personnel comprising the President, Junior Past-President, and Secretary of each of the five groups.)

The program (in condensed form) for the Cairo Congress is as follows:

RAW-MATERIALS AS AN INDUSTRIAL AND SOCIAL PROBLEM

Section A.—INDUSTRIAL RAW MATERIALS AND THEIR RATIONAL UTILIZATION THROUGHTOUT THE WORLD:

I.—Mineral Raw Materials (coal, petrol, ores, etc.).

II.—Vegetable and Animal Raw Ma-

Publications Available on Request for Student Use

THE inventory of certain publications issued a number of years ago is such that some reduction in the stock should be effected soon but before discarding a quantity of the books it is thought that they might be of service for student use or in certain engineering courses. Should any members of the Society, particularly faculty members, like to procure a reasonable number of copies of the following publications they will be transmitted without any other charges than the shipping costs.

Symposium on Correlation Between Accelerated Laboratory Tests and Service Tests on Protective and Decorative Coatings (1937).

Symposium on Impact Testing (1938).

Wire Test Report (1939).

Symposium on Significance of the Tension Test of Metals in Relation to Design (1940).

Symposium on the Significance of the Hardness Test of Metals in Relation to Design (1943).

Each of these special publications contains considerable information of value, even though they were issued a number of years ago, but the demand for them is such that only a limited number of copies need to be stocked, and additional space can be made available. Those who may want copies for student use are urged to write promptly, addressing the communication to the Office Manager, A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

terials (wood, cotton, rubber, wool, etc.).

All problems connected with raw materials; geographical distribution, exploitation, circulation and utilization, will be examined in their aspect related to industry; problems of energy do not come within the scope of Section A.

Section B.—Social Aspect of Technical Development and of Raw Material Problems:

This section covers all problems relating to dissemination and popularization of applied science and implications of industrialization on human life.

Section C.—The Problem of Water in the Middle-East:

I.—Waterways (Irrigation, Navigation, Power, Drinking Water).
II.—Seas.
III.—Subterranean Water (Irrigation, Drainage, Drinking Water).
IV.—Rain Water (Irrigation, Drinking Water, Artificial Rain).

Preprinted Paper on Magnetism in Copper Alloys

A paper on "Magnetism in Copper Alloys: The Effect of Iron as Impurity" by Allison Butts and Paul L. Reiber, Jr., will be presented at a meeting of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, to be held sometime in March. Preprint copies of this paper can be obtained upon request by anyone wishing to submit discussion. The paper and discussion will appear in the 1949 *Proceedings*.

1947–1948 Technical Manual and Yearbook A.A.T.C.C.

With a change in format and the new title of Technical Manual and Yearbook, the American Association of Textile Colorists and Chemists has published a new volume succeeding its old Year Book (although Volume XXIV in a series).

The new Manual consists of five sections: Part I covers Organization, that is, national and sectional officer personnel and the reports of various officers, meeting programs; Part II consists of Committee Reports, including the executive, research, and publications; Part III deals with A.A.T.C.C. Standard and Tentative Test Methods; Part IV lists dyestuffs and textile chemical specialties; Part V presents an alphabetical and geographical list of members.

The Technical Manual and Yearbook is published by the Howe Publishing Company, Inc., 1 Madison Ave., New York City.

National Electrical Safety Code

This handbook contains the first five parts of the fifth edition of the National Electrical Safety Code. Each of these parts has been approved by the American Standards Association as an American Standard. Part 6 of the code has not been included as it is being revised under a new and separate sectional committee. In addition to protective grounding rules, the five parts cover: rules for installation and maintenance of electric supply stations, electric supply and communication lines, electric utilization equipment; rules for radio installation.

Parts 1 to 5, inclusive, of the National Electrical Safety Code were revised separately by technical committees working under the Sectional Committee listed in the handbook. These parts have been issued separately as National Bureau of Standards Handbooks H31 to H35, inclusive. This volume combines these Handbooks under one cover. The page numbers of the separate Handbooks have been retained to assist in the location of specific code rules regardless of the volume used.

The National Electrical Safety Code is now used by over half of the states in their power transmission requirements, as well as by municipal governments, electrical power companies, telephone and telegraph systems, and railroads.

This 408-page Handbook is available at a price of $1.25 per copy through the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

The Specifications and Law on Engineering Works

Recognizing a definite need for a new approach to the subject of specifications and the law, Walter C. Sadler has presented this book as a practical aid for the engineer with little or no legal training. It is an integrated treatment of this important subject and provides a thorough foundation in engineering law for writing foolproof specifications. In addition to complete description of the engineer's commonly encountered legal problems, a summary of the historical significance of various legal systems is included to show how modern courts apply statutes to practical legal questions on engineering works. Among the topics specifically discussed, with examples taken from actual experience, are the legal instruments of contractual documents, illegal matters of concern to engineers, the law on agency partnerships and corporations, patents and workmen's compensation. A complete set of detailed contracts and specifications, covering the construction of a transmitter building for the University of Michigan, is given in the appendix.

Currently Professor of Civil Engineering at the University of Michigan, Mr. Sadler has had an outstanding record in engineering, law, and teaching. Holding degrees in both law and engineering, he has had general supervision of some 15,000 construction contracts. He served as consulting engineer on numerous railroad and municipal projects and was in charge of the renegotiation of wartime utility contracts of all government agencies in eight western states.

Copies of this 493-page publication (page size, 8½ by 5½ in.) can be procured from John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., at $5 per copy.

Thermal Expansion Data on Earth Materials

Very special and precise apparatus has been devised for use in research being conducted to determine fundamental thermal expansion data of high accuracy on earth materials. This research has been inaugurated at Rensselaer Polytechnic Institute and will cover a period of several years. Professors Joseph L. Rosenholtz and Dudley T. Smith are in charge of the project. Determinations will be made of the linear thermal expansion of rocks and crystallographically oriented mineral specimens at temperatures ranging from 20 to 1400 C. These data will be useful to industries that use and manufacture ceramic materials such as glass, tile, clay products, refractories, electrical insulators and resistors, etc.

Specimens are ¼-in. square prisms ½ in. long which are prepared by sawing mineral crystals parallel to their crystal axes. Diamond saws are used for most minerals. The microscopic changes in length of the half-inch specimens with increasing temperatures are measured by an extensometer and may be magnified up to approximately 2000 times and automatically recorded as a deformation-time curve. This equipment incorporates a self-balancing transformer bridge which is sensitive to length changes of the order of two millionths of an inch.

Data for a single specimen may require a day including time for preparing the test. If several specimens of each material are tested, the total time required for each material may be several weeks since some minerals must be studied in three directions, requiring at least nine determinations plus the time for cutting and for setting up.

Although the research work is a full-time project only during the summer, the fact that the equipment is fully automatic in operation after being set up and needs no attendant, makes it practicable to obtain a large volume of data during the scholastic year.

Bulletin Index Furnished on Request

Reprints have been struck off of the Subject and Author Indexes for the six issues of the 1948 ASTM Bulletin, and copies will be sent without charge on request to any member or Bulletin subscriber. A number of members, libraries, and others bind the Bulletin, and many like to have the Subject and Author Index bound in separately from the December ASTM Bulletin, where the indexes are published.

New Members to January 3, 1949

The following 77 members were elected from November 15, 1948, to January 3, 1949, making the total membership 6544.

Names are arranged alphabetically—company members first, then individuals.

Chicago District

LABORATORY EQUIPMENT CORP., George J. Krasl, Vice-President and Research Chemist, Box 68, St. Joseph, Mich.

COMESS, SAM, Owner, Mid-West Engineering Co., 1018 Mound St., Davenport, Iowa.

HAUBER, CECIL, Head, Civil Engineering Dept., Tri-State College, Angola, Ind.

LAULETTA, PAUL A., Metallurgist, Joslyn Manufacturing and Supply Co., Fort Wayne 6, Ind.

LIBRARY OF INDUSTRIAL RESEARCH, S. Pittacora, Research Dept., Chicago 10, Ill.

MCKEE, JAMES CAVANAUGH, Civil Engineer, 9204 S. Blackstone Ave., Chicago 19, Ill. [J]*

PRESLER, ALDEN FREDERICK, Chemical Engineering Graduate Student, University of Minnesota, Minneapolis, Minn. For mail: 355 Kenneth St., St. Paul 5, Minn. [J]

RICH, BARRETT G., Chief Engineer, John Deere Waterloo Tractor Works, Waterloo, Iowa.

SCOTT, VERNON ROBB, Metallurgist, Dickson Weatherproof Nail Co., 1900 Greenwood, Evanston, Ill. For mail: 1504 Highland Ave., Wilmette, Ill.

SHOOP, J. W., Vice-President, The Lehon Co., 4425 S. Oakley Ave., Chicago 9, Ill.

SLATE, FLOYD O., Assistant Professor and Research Chemist, Purdue University, Lafayette, Ind.

Cleveland District

DILLON, GORDON P., Chief Chemist, Shellmar Products Corp., Mt. Vernon, Ohio.

JONES, WILLIAM M., Vice-President and General Sales Manager, The Cleveland Quarries Co., 1740 E. Twelfth St., Cleveland 14, Ohio.

Detroit District

EBERBACH AND SON CO., INC., Robert O. Eberbach, Treasurer and General Manager, Box 63, Ann Arbor, Mich.

GLASS FIBERS, INC., E. L. Clayton, Research Supervisor, Waterville, Ohio.

STARECK, J. E., Director of Research, United Chromium, Inc., 2751 E. Jefferson Ave., Detroit 7, Mich.

New England District

PRESMET CORP., THE, Carl G. Johnson, Vice-President, 112 Harding St., Worcester 4, Mass.

BURESH, FRANCIS M., Textile Engineer, Otis Rd., Blandford, Mass.

MORRILL, CARLETON E., Chemist, Pepperell Manufacturing Co., Lewiston, Me.

TAYLOR, SCHUYLER J., Technical Director, The Russell Manufacturing Co., Middletown, Conn.

New York District

BUDRECKI, HERBERT R., Student, Fordham University, Fordham Rd., Bronx, N. Y. For mail: 300 Court St., Elizabeth 1, N. J. [J]

CHESS, H. B., Metallurgist, The Torrington Co., Standard Plants, Prospect St., Torrington, Conn.

COUTURE, EDWARD G., Supervisor of Methods, The Plume and Atwood Manufacturing Co., Thomaston, Conn.

DIERKENS, FERDINAND, Belgian American Educational Foundation, 420 Lexington Ave., New York, N. Y. For mail: 1288 N. Sixty-third Court, Wauwatosa 13, Wis. [J]

FISS, W. B., Electrical Engineering Dept., Consolidated Edison Company of New York, Inc., 4 Irving Pl., New York 3.

GREEN, GILES G., Assistant Professor of Civil Engineering, In Charge, Materials Testing Lab., Cooper Union, Cooper Square, New York 3, N. Y.

LEISTNER, W. E., Research Director, Argus Chemical Laboratory, Inc., 56 Clifton Pl., Brooklyn 5, N. Y.

MAUTNER, STEVEN E., Vice-President and Chief Engineer, Skydyne, Inc., Port Jervis, N. Y. For mail: 170 E. Main St., Port Jervis, N. Y.

MUCHEMORE, STEPHEN E., Chief Structural Engineer, Lockwood Greene Engineers, Inc., 10 Rockefeller Plaza, New York 20, N. Y. For mail: 36 Quintard Dr., Port Chester, N. Y.

PAYNE, V. F., Deputy Chief, Components and Materials Branch, Signal Corps Engineering Laboratories, Fort Monmouth, N. J. For mail: 400 Atlantic Ave., Long Branch, N. J.

RICHTER, GERHARD L., Metallurgist, Farrel-Birmingham Co., Inc., Ansonia, Conn.

STEWART, ERNEST RICHMOND, Technician, William Skinner and Sons, 45 E. Seventeenth St., New York 3, N. Y.

WILD, MAX, Technician, Martin Weiner Co., 225 Clifton Blvd., Clifton, N. J. For mail: Franklin Gardens, Apt. J-16, Clifton, N. J.

Northern California District

CALDWELL, D. H., Partner, Brown & Caldwell, 233 Sansome St., San Francisco 4, Calif.

FRESNO STATE COLLEGE LIBRARY, H. Margaret Harden, Supervising Librarian, Fresno 4, Calif.

Ohio Valley District

(In Course of Organization)

AMERICAN FLURESIT CO., W. M. Spurgeon, Research Director, 635 Rockdale, Cincinnati 29, Ohio.

OHIO-APEX, INC., Paul E. Willard, Research Chemist, Nitro, W. Va.

ROQUEMORE, G. F., Technical Manager, Caram Chemical Co., Grove City, Ohio.

SMITH, HERBERT A., Chemist, The Mead Corp., Ninth and Paint Sts., Chillicothe, Ohio.

Philadelphia District

BICKING, CHARLES ALBERT, Quality Control Engineer, Hercules Powder Co., Wilmington 99, Del.

KLEMME, WHELAN W., JR., Chemist, Hercules Powder Co., Experiment Station, Wilmington, Del. For mail: 17 New St., Newark, Del. [J]

SIEMINSKI, MITCHELL A., Textile Technologist, The Jaunty Fabric Corp., Park and Poplar Sts., Scranton 9, Pa.

Pittsburgh District

MACLAREN, A. W., Assistant Metallurgical Engineer, Bar and Semi-Finished Products, Carnegie-Illinois Steel Corp., 867 Frick Bldg., Annex, Pittsburgh 30, Pa.

St. Louis District

BROUK, J. JOHN, Vice-President, Precast Slab and Tile Co., 1367 S. Kingshighway, St. Louis 12, Mo.

KANSAS, STATE GEOLOGICAL SURVEY OF, Norman Plummer, University of Kansas, Lawrence, Kans.

MOEHRL, KENNETH E., Director of Research, Layne & Bowler, Inc., Box 215, Hollywood Station, Memphis 8, Tenn.

Southern California District

MOTION PICTURE RESEARCH COUNCIL, INC., Betty Walkey, Engineering Librarian, 1421 N. Western Ave., Hollywood 27, Calif.

PROWELL, H. D., Owner, H. D. Prowell Co., 1855 Industrial St., Los Angeles 21, Calif.

Washington (D. C.) District

CLOVER, PAUL B., Specifications Engineer, 1928 Eye St., N. W., Washington 6.

GREENFELD, SIDNEY H., Research Chemist, Asphalt Roofing Industry Bureau, National Bureau of Standards, Washington, D. C. For mail: 2500 Jefferson St., Wilmington, Del. [J]

LIVINGSTON, R. W., Materials Engineer, U. S. Army Engineers, Washington, D. C.

SCHWARTZ, JAMES I., Research Associate, National Bureau of Standards, Washington 25, D. C. For mail: 1340 Michigan Ave., N. E., Washington 17, D. C. [J]

U. S. and Possessions

CONCRETE PRODUCTS ASSOCIATION OF WASHINGTON, C. M. Howard, Engineer, 416 Arctic Bldg., Seattle 4, Wash.

ENGINEERS TESTING LABORATORY, INC., V. S. Skinner, Manager, 3313 Main St., Houston 4, Tex.

HARRIS STANDARD PAINT CO., INC., M. J. Catena, Vice-President, Box 1870, Tampa 1, Fla.

BIRDWELL, EFFIE, Librarian, Monsanto Chemical Co., Texas Div., Texas City, Tex.

BRINK, EDWIN H., Assistant Director of Research, Masonite Corp., Laurel, Miss.

GOARD, HOWARD W., Chemical Engineer, Phillips Petroleum Co., 615 S. Dewey, Bartlesville, Okla. [J]

GRANT, LAWRENCE S., Inspector, U. S. Treasury Dept., Supply Center, Fort Worth, Tex. For mail: 1321 Chartres St., New Orleans 16, La.

LARSON, HARRY, Lieutenant Colonel, Corps of Engineers, U. S. Department of the Army, 725 Cooper Bldg., 1009 Seventeenth St., Denver 2, Colo.

NATURAL RESOURCES RESEARCH INST., H. G. Fisk, Director, University of Wyoming, Laramie, Wyo.

PHIPPS, FRANK W., Construction Engineer, Bureau of Yards and Docks, U. S. Department of the Navy, c/o OICC NOy 13913, NOB Adak, Alaska.

THEUER, ARTHUR U., Departmental Materials Engineer, Fay, Spofford & Thorndike, Alaskan Facilities, Fort Richardson, Anchorage, Alaska.

Other than U. S. Possessions

ABAZOGLOU, JOSEPH A., Chief Engineer, The Hellenic Copper Industries, S. A., 14 Pesmadjoglou Str., Athens, Greece. For mail: 27a Mithimnis Str., Athens, Greece.

AUSTRALIA, DEPARTMENT OF WORKS AND HOUSING, Librarian, 271 Collins St., Melbourne, Victoria, Australia.

BOGADO, E. J., Chief Chemist, Cia. Argentina de Cemento Portland, Parana, Argentina.

CENTRE NATIONAL DE RECHERCHES METALLURGIQUES, P. Coheur, Directeur, 2 rue Armand Stevart, Liege, Belgium.

COLBECK, ERIC WINEARLS, Metallurgical and Research Director, Hadfields, Ltd., East Hecla Works, Sheffield 9, England.

COLLINS, ALFRED DREW, Chemist, Dominion Lead Mills, Ltd., Box 40, Newmarket, Auckland, New Zealand.

DAS GUPTA, RANENDRA CHANDRA, Chemist, Government Test House, Alipore, Calcutta 27, India. For mail: 2/1 Ballygunge Gardens, Calcutta 19, India.

DAVIDSOHN, ALFRED, Research Chemist, Palestine Oil Industries, Ltd., Shemen, Box 1102, Haifa, Palestine.

GRUBB, KJELD T., Proprietor, H. Struers Chemiske Laboratorium, 38 Skindergade, Copenhagen K, Denmark.

JAMES, W., Superintendent, Technical Service Div., Standard-Vacuum Petroleum Mij., Soengei Gerong, Palembang, Sumatra, Indonesia.

LARANJA, F., Chief Chemist, Cia. Nacional de Cemento Portland, Rio de Janeiro.

SHIH, H. C., Manager, Foreign Industrial Relations, Hsin Hwa Engineering Co., Suite 401, 246 Kiangse Rd., Shanghai, China. For mail: House 8, Lane 297 Route Delastre, Shanghai 18, China.

SIBLEY, JOSEPH J., Management Engineer, Casilla 1213, Santiago, Chile.

SZWARC, ALEXANDER, Technical Director, Arborite Co., Ltd., 385 Lafleur Ave., Ville LaSalle, Montreal, P. Q., Canada.

* [J] denotes Junior Member.

PERSONALS • • •

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as the key letter. It is believed this arrangement will facilitate reference to the news about members.

At the National Metal Congress in Philadelphia in November many leading men concerned with the steel industry, both from the standpoint of production and use of the materials, received American Society for Metals Awards for Distinguished Service. As might be expected, a good many of these men who have made notable contributions to alloy steel development are members or have been active on A.S.T.M. technical committees. A review of the list of recipients and a study of their contributions which merited the awards impresses one with the tremendous technical skill and capabilities which have resulted in so many advances in the production and use of alloy steel. About thirty of the men who received the awards were A.S.T.M. members, their names having been publicized in the trade literature.

Julian Alexander, Jr., formerly associated with the Houdry Process Corp., Marcus Hook, Pa., is now with the American Petroleum Institute, Div. of Refining, New York City.

C. R. Barton has retired as Vice-President of the Spang-Chalfant Division of the National Supply Co., Ambridge, Pa. Mr. Barton had been representative of Spang-Chalfant membership in A.S.T.M. since 1924. **S. H. Kilmer,** Superintendent of Inspection, who has long been active in Technical Committee A-1, is taking over the company representation in the Society.

William H. Bassett, Jr., who had returned to civilian life for several months and had been affiliated with Anaconda Wire & Cable Co., New York City, as Industrial Consultant, is again with the U. S. Ordnance Dept., having been assigned Commanding Officer of the Birmingham, Ala., District, covering several of the southern states.

Stephen Webster Benedict, formerly Materials Engr., National Bureau of Standards, Washington, D. C., is now Director of Research, Master Builders Research Laboratories, Cleveland, Ohio.

Samuel A. Bloom has accepted appointment as Technical Director, Baltimore Paint and Color Works, Baltimore, Md. He was previously associated with the Titanium Pigment Corp., New York City.

Carl F. Braun, President of **C. F. Braun and Co.,** Alhambra, Calif., manufacturers of heat exchangers for the oil industry, has been awarded honorary membership in The American Society of Mechanical Engineers, Mr. Braun being one of five engineers and scientists so honored by A.S.M.E. at its recent annual meeting. His citation notes that as a "creative engineer and researcher in heat transfer, his work has helped point the way to equipment and methods that are now standard in the oil industry" and emphasizes that he has been outstanding as a "champion of improvement in the relation between management and labor, possessing wisdom and vision in the problems of capital, labor, and the public."

The Chemists' Club of New York City, which group holds membership in A.S.T.M., has issued an interesting brochure covering "Fifty Years of History," and appropriate ceremonies were held at the Club on December 9, 1948. The organization, with headquarters at 52 East 41st St., has almost 2300 members, an excellent club building, and is a center for exchange of thought and information among chemists. The Club has laid much emphasis on the development of its Library. A number of A.S.T.M. members are active in the Club.

Richard E. Deaux, formerly Process Engineer, Gibson Refrigerator Co., Greenville, Mich., is now Chief Engineer, The Coolerator Co., Duluth, Minn.

Francis B. Foley, Superintendent of Research, The Midvale Co., Philadelphia, has been selected as the 1950 Howe Memorial Lecturer by the Board of Directors of the American Institute of Mining and Metallurgical Engineers. A Past-President of the A.S.M., Mr. Foley has been very active in the work of A.S.M. and other organizations.

John W. Harsch, Chief Engineer of Leeds & Northrup Co., Germantown, Philadelphia, Pa., recently observed the 25th anniversary of his employment by the firm which manufactures electrical measuring instruments, automatic controls, and heat-treating furnaces. In official recognition of the anniversary Charles S. Redding, President of Leeds & Northrup, presented Mr. Harsch with a 25-year insert for the plaque awarded him on his 15th anniversary. Mr. Harsch is a long-time A.S.T.M. member, and has been an active member of Committee B-4 for more than 25 years, and is immediate Past-Chairman.

Wendell F. Hess, Head, Department of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y., was one of fourteen scientists and engineers recently awarded Army-Navy Certificates of Appreciation. Professor Hess's wartime services covered the conducting and supervising of a program of metallurgical research for the Office of Scientific Research and Development, including the prediction of cooling rates and welding conditions in welding steels, the surface preparation of magnesium sheets for spot welding, and factors involving cracking in arc welding.

Sydney B. Levinson, formerly associated with Adco Chemical Co., Newark, N. J., is now Plant Manager and Technical Director, The Garland Co., Cleveland, Ohio.

Charles Swain Lumley is now Executive Vice-President of the H. E. Beyster Corp., Detroit, Mich. He was previously Manager, Industrial Div., Smith, Hinchman & Grylls, Inc., of the same city.

Robert W. Matlack, President, George D. Wetherill and Co., Inc., Philadelphia, is the newly elected President of the Federation of Paint and Varnish Production Clubs. Mr. Matlack, who has been with the Wetherill Co. since 1931, became Assistant Technical Director in 1933, was named Director in 1938, was elected Secretary of the firm in 1935, and became President in 1943. He has been active in the affairs of paint trade organizations for some time. He is an active member of A.S.T.M. Committee D-1 on Paint, Varnish, Lacquer and Related Products, and serves on the Joint F.P.V.P.C.-A.S.T.M. Committee on Paint, Varnish, and Lacquer as representative of the Federation.

The Midwest Research Institute, Kansas City, Mo., has announced the appointment of George E. Ziegler as Director, and Clayton O. Dohrenwend as Assistant Director of the Institute.

J. Strother Miller, long-time member and Honorary Member of the Society, and prior to his retirement in 1942 Director of the Technical Department of the Barber Asphalt Corp., has moved from 1084 Cryant St., Rahway, N. J., to 13 Campus Drive, Buffalo 21, N. Y., where he will continue his consulting practice in asphalt technology. Mr. Miller is the present Chairman of Committee D-8 on Bituminous Waterproofing and Roofing Materials.

Sherman Monroe, formerly with the Commercial Testing Labs., Clifton, N. J., is now on the staff of the Burlington Mills Corp., New York City.

Howard K. Nason, member of the A.S.T.M. Board of Directors and very active in the work of certain technical committees, in particular Committee D-20 on Plastics, has been appointed Acting Director of the Central Research Dept., Monsanto Chemical Co., in Dayton, Ohio. Mr. Nason has been Associate Director since 1946, and prior to that was Director of Development. Dr. Carroll A. Hochwalt, Vice-President formerly in charge of the Central Research Dept., is now responsible for coordinating all of the company's research and development activities. A number of other major changes in the Monsanto's administrative organization have been announced and are covered in some detail in the December *Monsanto Magazine*.

Harald M. Olson, formerly associated with the Ohio Salt Co., Wadsworth, Ohio, has been named Consulting Maintenance Engineer for the Morton Salt Co., Chicago. Mr. Olson will continue his endeavors as heretofore in the fields of water treatment and corrosion problems, as well

as his activities as general chairman of the Annual Industrial Water Conference of the Engineers Society of Western Pennsylvania, Pittsburgh.

John M. Roberts recently retired as President of the Scientific Apparatus Makers of America. He was honored at the S.A.M.A. Mid-Year Meeting at French Lick Springs in October by election to Honorary Membership and presentation of a beautifully engrossed and illuminated parchment scroll containing the text of a Board resolution thanking him for his many years of leadership and service. Mr. Roberts, who has been active in A.S.T.M. technical committee work, particularly in the Section on Laboratory Glassware of Committee E-1 on Methods of Testing, plans to continue certain of his contacts in connection with standardization in the apparatus industry. Kenneth Andersen, previously affiliated with the National Electrical Manufacturers Association, is now Executive Vice-President of the Scientific Apparatus Makers of America, with Headquarters at 20 N. Wacker Drive, Chicago, Ill.

Roscoe H. Sawyer, formerly Research Supervisor, E. I. du Pont de Nemours and Co., Inc., Newport, Del., is now Asst. Chemical Director, Devoe & Raynolds Co., Inc., Louisville, Ky.

Walter M. Scott, Director, U. S. Department of Agriculture Southern Regional Research Laboratory, New Orleans, and **J. H. Coulliette,** Director, Industrial Research Institute, University of Chattanooga, also **William G. Van Note,** Director, Engineering Experiment Station, North Carolina State College, are among the group of leading college and research laboratory directors who have been named to the Advisory Board of the new scientific journal to be issued by the Southeastern Research Institute, Inc., Atlanta, Ga. There are a large number of Federal, university, and industrial research laboratories in the southeastern United States and the new journal will provide a medium of expression for this research group.

William E. Sprague is now Field Engineer, Pacific Gas & Electric Co., Quincy, Calif. He was previously Junior Engineer, Sprague Chemical, Quincy.

Announcement has been received from the **Uruguayan Standards Institute** (Instituto Uruguayo de Normas Tecnicas) in Montevideo, of the election of Juan P. Molfino as President, and Augusto Hareau as Secretary. This organization has been a member of A.S.T.M. for a number of years.

Walter M. Weil is now President of the Enesco Corp., Cleveland, Ohio., formerly known as the National Smelting Co., of which company Mr. Weil had been Treasurer.

Eric Weyl has opened offices as a Textile Engineering Consultant, Manchester, N. H. He was previously affiliated with the Chicopee Mfg. Corp., Chicopee Falls Mass., as Consultant Textile Engineer.

J. C. Witt, for the past ten years Technical Director of Marquette Cement Mfg. Co., Chicago, Ill., is now Consulting Engineer.

E. Y. Wolford has been named Manager of Plastics Development for the Chemical Division of Koppers Co., Inc., Pittsburgh, Pa. Mr. Wolford has been with Koppers Co. since 1942, and represents his company on A.S.T.M. Committees D-9 on Electrical Insulating Materials, D-14 on Adhesives, and D-20 on Plastics.

Charles E. Wuerpel, formerly with the U. S. Dept. of the Army Corps of Engineers, Washington, D. C., is now Technical Director, Marquette Cement Mfg. Co., Chicago, Ill.

LeRoy L. Wyman, Research Metallurgist, General Electric Co., Schenectady, N. Y., was the recipient of an Army-Navy Certificate of Appreciation at exercises at Rensselaer Polytechnic Institute, Troy, N. Y., in December, when a group of scientists and engineers were honored for wartime services. Mr. Wyman's award was in recognition of service as Research Supervisor, War Metallurgy Division, Office of Scientific Research and Development, in charge of numerous Army and Navy research projects in the properties and wartime use of the light and nonferrous metals.

News of Instrument Companies and Personnel

JAMES W. DICE, formerly with Westinghouse and more recently Assistant Sales Manager, Sperry Products, Inc., announces the formation of a new sales and development organization to be known as J. W. Dice & Co. Headquarters are at Grand View-on-Hudson, N. Y. This new company is specializing in the marketing of industrial and laboratory nondestructive test instruments employing magnetic, electronic, ultrasonic, and radiation principles. Marketing rights have been obtained for a number of test instruments manufactured here and abroad, and other specialized test devices are under development by the company.

The firm of SAM TOUR & CO., INC., consulting engineers, 44 Trinity Place, New York 6, N. Y., has augmented its staff by securing the services of Mr. Robert E. Barnett, B.S., who has had extensive experience in atmospheric sampling and analysis.

The YOUNG TESTING MACHINE CO., of Narberth, Pa., has recently been organized and offers a full line of strain gage equipment and testing machines, suitable for tension, compression, flexure, torsion, fatigue, and creep testing. Testing machines range in capacities from 1 lb. to 5,000,000 lb. The company's President, H. Russell Young, was until recently Chief Engineer of Baldwin's Testing Machine Division, where he supervised engineering of the large 5,000,000-lb. testing machine at the Philadelphia Naval Air Material Center. Folders can be procured by writing the company, Box 77, Narberth, Pa.

National Bureau of Standards Notes

LYMAN J. BRIGGS, Director Emeritus of the Bureau, was one of five outstanding scientists awarded honorary memberships by The American Society of Mechanical Engineers at its 69th Annual Meeting in New York City in December. Dr. Briggs, who spent 49 years in the technical service of the government, was chairman of the original Uranium Committee to study the use of atomic energy in warfare. Among his 39 inventions and contributions to science are: a stable zenith instrument for accurately firing naval guns; a new method of measuring acceleration of gravity at sea; an earth inductor compass for aiding airplane navigation; scientific instruments for stratosphere balloon flights; instruments used in the total solar eclipse expedition to Brazil, oceanographic studies, and modern methods of classifying soils. Dr. Briggs was always interested in the work of A.S.T.M. and lent his support to many joint projects of the Bureau and the Society.

BRUCE L. WILSON has been designated Chief of the Engineering Mechanics Section to succeed Walter Ramberg who has been Chief of the Section since 1946. This appointment relieves Mr. Ramberg, in order to discharge more effectively his primary duties as Chief of the Mechanics Division. Both Mr. Wilson and Mr. Ramberg are A.S.T.M. members.

A RECENT change in the Metrology Division of the National Bureau of Standards will be of interest to the membership. Howard S. Bean, widely known for his extensive work in the field of fluid measurements and on the application of rate-of-flow meters to the fuel gas industry, has been given added responsibilities as Chief of the newly formed Capacity, Density, and Fluid Meter Section of the National Bureau of Standards. The new section was formed by consolidation of the Gas Measuring Instrument Section, of which Mr. Bean has been Chief, and the Capacity and Density Section. E. L. Peffer, former Chief of the latter group, died on July 2, 1948. A native of California where he received his degree in Mechanical Engineering, Mr. Bean has been at the Bureau since 1917. An outstanding authority in the field of gaseous fuels, particularly involving the measurement of gas, Mr. Bean has been active for many years in A.S.T.M. Committee D-3 on Gaseous Fuels, and has served on Committee E-1 on Methods of Testing. As Chairman of the D-3 Subcommittee on Measurement of Gaseous Samples, he has directed a considerable amount of research work in this field.

Correction Note on Appointments

OUR October BULLETIN erred in indicating that H. L. Whittemore had been appointed to the R. L. Templin Award Committee. This should have indicated that Thomas J. Dolan, Research Professor of Theoretical and Applied Mechanics, University of Illinois, had accepted appointment to this Award Committee, and will serve with Messrs. R. E. Peterson, Westinghouse Electric Corp., *Chairman*, and M. F. Sayre, Union College, who have holdover terms.

Frank L. Wright Honored by Grease Committee

Upon his retirement as Chairman of Technical Committee G on Lubricating Grease, which functions under A.S.T.M. Committee D-2 on Petroleum Products and Lubricants, Frank L. Wright, Manager of Research, Norma-Hoffmann Bearings Corp., was honored by the committee with formal resolution presented to him as an attractive scroll. Mr. Wright has been chairman of this very active committee since its inception in January, 1945, and has been largely responsible for the accomplishments of the committee.

The citation appearing on the scroll reads as follows:

> "The Members of Technical Committee G on Lubricating Grease of the American Society for Testing Materials extend to you upon your retirement as Chairman, since the organization of the Committee, grateful appreciation of your able guidance, your constant encouragement and your kindly and appreciative consideration of their manifold problems. To you, above all others, belongs the credit for the successes during the past years.
>
> On behalf of and by the direction of all the members of the Committee.
>
> Robert C. Adams
> *Chairman*
> Carl W. Georgi
> *Vice-Chairman*
> Gus Kaufman
> *Secretary*
>
> June 22, 1948

Mr. Wright initiated the plan of having interesting technical papers on the testing of greases presented before the committee and at A.S.T.M. meetings. During his term as chairman, there were eleven such technical papers presented, all of which have been published in the ASTM Bulletin.

The committee has completed four methods for analysis and testing greases, and has under consideration additional procedures. The work of this technical committee is devoted to three broad types of testing, namely, identification, inspection or quality control, and performance.

Mr. Wright, who is a member of the D-2 Advisory Committee, will continue as a member of Technical Committee G.

NECROLOGY

In the death of William Gaertner, Founder and President of the Gaertner Scientific Corp. of Chicago, the Society loses a long-time member who, although not active technically, had been keenly interested in aiding the Society's work. (Representative of Company Membership since 1923.) This company is one of the leading manufacturers of precision and scientific instruments, particularly astronomical equipment, and instruments in such fields as spectrography, interferometry, and others. He was 84 years old when he died on December 3, 1948, and to carry on his business Mr. Gaertner created a living trust such that the University of Chicago, which is the beneficiary of the company, is required to maintain the company as a business for at least 21 years after the death of Mrs. Gaertner. This provision was set up in part so that a number of the loyal employees of Mr. Gaertner will continue with the business. Mr. Gaertner's trust gift to the University ties back to his arrival from Germany in the early 1890's, when he was encouraged by Professor A. A. Michelson and began his instrument work in a shop near the University.

Dr. Samuel Jacobsohn, Executive Vice-President of the company, is a member of Committee E-2 on Spectrographic Analysis.

Howard H. Leh, Vice-President, Keystone Portland Cement Co., Bath, Pa. (December 5, 1948). Representative of Company Membership since 1930, and representative of his company on Committee C-1 on Cement since 1933.

Tom Lehon, Vice-President and General Manager, The Lehon Co., Chicago, Ill. (September 9, 1948). Member since 1923.

Calendar of Society Meetings

American Society of Heating and Ventilating Engineers—International Exposition, January 24–28, International Amphitheatre, Chicago, Ill.

American Institute of Electrical Engineers—Winter General Meeting, January 31–February 4, Pennsylvania Hotel, New York, N. Y.

Steel Founders' Society of America—Annual Meeting, February 9–10, Chicago, Ill.

American Institute of Mining and Metallurgical Engineers—Annual Meeting, February 13–17, San Francisco, Calif.

American Society for Testing Materials—Spring Meeting and Committee Week, February 28–March 4, Edgewater Beach Hotel, Chicago, Ill.

American Institute of Chemical Engineers—Regional Meeting, March 6–10, Los Angeles, Calif.

Manufacturers' Standardization Society of Valve and Fittings Industry—Annual Meeting, March 7–10, Commodore Hotel, New York, N. Y.

American Gas Assn.—Distribution Motor Vehicle and Corrosion Conference, April 4–6, Netherlands-Plaza Hotel, Cincinnati, Ohio.

American Society for Metals—6th Western Metal Congress and Western Metal Exposition, April 11–15, Shrine Auditorium, Los Angeles, Calif.

National Assn. Corrosion Engineers—April 11–13, Netherlands-Plaza Hotel, Cincinnati, Ohio.

National Petroleum Assn.—April 13–15, Hotel Cleveland, Cleveland, Ohio.

Midwest Power Conference—11th Annual Meeting, April 18–20, Hotel Sherman, Chicago, Ill.

American Institute of Electrical Engineers—Southwestern District Meeting, April 20–22, Dallas, Tex.

Southern Gas Assn.—Convention, April 20–22, Buena Vista Hotel, Biloxi, Miss.

American Society of Mechanical Engineers—Spring Meeting, May 2–4, New London, Conn.

American Foundrymen's Society—53rd Annual Foundry Congress, May 2–5, St. Louis, Mo.

Instrument Society of America—4th Annual Spring Meeting, May 12–13, Royal York Hotel, Toronto, Canada.

American Water Works Assn.—Annual Conference, May 30–June 3, Stevens Hotel, Chicago, Ill.

Society of Automotive Engineers—Summer Meeting, June 5–10, place to be determined.

American Institute of Electrical Engineers—Summer General Meeting, June 20–24, New Ocean House, Swampscott, Mass.

American Electroplater's Society—36th Annual Convention, June 27–30, Schroeder Hotel, Milwaukee, Wis.

American Society of Mechanical Engineers—Semi-Annual Meeting, June 27–30, San Francisco, Calif.

American Society for Testing Materials—52nd Annual Meeting, June 27–July 1, Hotel Chalfonte, Haddon Hall, Atlantic City, N. J.

To the A.S.T.M. Committee on Membership

1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on membership in A.S.T.M. and include a membership application blank

Signed _____

Address _____

Date _____

Notes on Laboratory Supplies

Catalogs and Literature; Notes on New or Improved Apparatus

This information is based on literature and statements from apparatus manufacturers and laboratory supply houses.

Catalogs and Literature

Tinius Olsen Testing Machine Co., Easton Road, Willow Grove, Pa. Bulletin 36 entitled "Testing Machines for Plastics" has recently become available. This folder describes the twelve types of Olsen testing equipment for testing plastics. Those instruments covered in detail include the Plastiversal, Lo-Cap, Electronic Recorder, Torsion Tester and Load Deformation Tester, Plastic Impact Tester, Wearometer, and several others, including specialized accessories and tools. Throughout the bulletin the A.S.T.M. specification is given with each machine. 32 pages, illustrated.

Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. Catalog TB2-621 entitled "Vapocarb-Hump" (the triple-control method for heat treatment of steel). This publication describes the triple-control method which regulates atmosphere, rate of heating, and quench point to provide hardened steel of proper surface, shape, and structure. It shows how the heat-treating method is easily modified for carburizing and gas cyaniding so that desired case depth is obtained through the use of atmosphere and temperature control, and an automatically drawn record indicating the time at soak. Featured for the first time is an improved method for controlling Vapocarb atmosphere through the use of a fluid pump assembly, flow setter and other attachments upon the control panel. 32 pages, illustrated.

Humboldt Mfg. Co., 2014 N. Whipple St., Chicago 47, Ill. Catalog 15 entitled "Testing Equipment" covers equipment for asphalt, tar, petroleum products, cement, concrete, aggregates, sub-soils, including testing sieves, balances, and weights. A.S.T.M. designations are listed with some of the equipment. Each piece of equipment is described in detail, and illustrated. 62 pages.

Parr Instrument Co., 211 Fifty-Third St., Moline, Ill. An 80-page publication on "Oxygen Bomb Calorimetry and Oxygen Bomb Combustion Methods," intended primarily to provide a complete reference handbook for users of the Parr apparatus, but contains a wealth of basic information on all phases of its subject. The range of topics discussed extends all the way from basic principles through a description of the apparatus and all steps of the test procedure, and includes chapters on causes of error and on maintenance and safety instructions. The apparatus described and the detailed information given for its best use are pertinent to the several A.S.T.M. methods employing the oxygen bomb in determinations of calorific value, sulfur, and chlorine in coal, coke, and petroleum products. Complimentary copies of this booklet may be obtained by writing the Parr Instrument Co. and asking for "Parr Manual No. 120."

Corning Glass Works, Corning, N. Y. Supplement A, Catalog No. LP28, covering a number of new items and price revisions, is entitled "Laboratory Glassware." The "New Items" Section 1 includes flasks, funnels, jars, kettles, stopcocks, etc. Section 2 covers revised prices, effective November 15, 1948, superseding all prices in Catalog LP28. Illustrated, 74 pages.

Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. Catalog CEC-1300A, entitled "Analytical Instruments for Science and Industry," presents in brief form the complete line of precision instruments designed and manufactured by Consolidated Engineering. The instruments in the catalog are divided into two sections: Mass Spectrometry and Static-Dynamic Measuring and Recording, the first section featuring two new developments in mass spectrometry, together with well-established C.E.C. instruments and associated equipment, and the second, three complete systems for measuring and recording, together with associated equipment. A section is devoted to description of new multielement Recording Oscillographs which incorporate many outstanding features heretofore not available in standard instruments. 15 pages, illustrated.

E. H. Sargent & Co., 155-165 E. Superior St., Chicago 11, Ill. This publication entitled "Scientific Apparatus and Methods" (Including Latest Catalog Revisions) is published quarterly by Sargent. This Fall, 1948 edition covers High Precision in Polarographic Analysis; A New Sargent Relay for Constant Temperature Baths; The Purification of Mercury; The Determination of Specific Gravities of Whole Blood and Plasma Using Copper Sulfate Solutions; Section 2 covers new scientific apparatus, reinstated items, discontinued items, and changes in specifications. Illustrated.

Scientific Glass Apparatus Co., Inc., Bloomfield, N. J. A leaflet entitled "What's New for the Laboratory" describes several items including a new heavy-duty stirrer, adapter, water stills, balance, laboratory ovens, time switch, etc. Illustrated.

Bausch & Lomb Optical Co., 636 St. Paul St., Rochester, N. Y. A 19-page folder, Catalog D-15, entitled "Bausch & Lomb Stereoscopic Wide Field Microscopes," describes briefly fifteen models to answer all needs. A new "Junior Line," wider field coverage, dustproof nosepiece and optical system, wider focusing rack, double extension slides, geared eyepieces for interpupillary setting, redesigned eyepieces with higher eyepoint. The larger size illustrations show every detail including the "New Look" gray enamel finish. 20 pages.

Buehler Ltd., 165 W. Wacker Drive, Chicago 1, Ill. A six-page leaflet, "Surfacers and Grinders," describes two types of wet power grinders, a bench grinder, a belt surfacer, and a duo-belt wet surfacer. Illustrated.

Instrument Notes

New Metal Cases—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. These new cases are not only more modern in appearance, but sturdier and better able to stand rough handling. Their gray baked enamel finish is hard and durable—resists scratching and is easy to keep clean.

New Analyzer for Quality Control and Sorting of Metal Parts—J. W. Dice & Co., 191 River Road, Grand View-on-Hudson, N. Y. The Model C Cyclograph is a new portable instrument, operating on the core loss principle, for rapid and nondestructive metallurgical examination and sorting of metal parts. The wide range of test frequencies available in the new instrument (2 kc. to 200 kc.) makes possible a variety of nondestructive tests. The Model C is particularly applicable to the checking or sorting of metal parts on the basis of analysis, structure, hardness, case depth and in some cases stress concentration. This Model can be used to trace internal stress changes, compare stresses at different levels, or measure stress in psi. (by calculation). The Model C, being portable, can be used anywhere within a plant.

Standard Soiled Fabrics—United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J. In the evaluation of detergents and to determine the efficiency of washing machines and related equipment, the use of soiled fabrics is necessary, and U. S. Testing has announced a project to make available standard soiled fabrics of cotton, wool, acetate, viscose and other textile materials. The company made an extensive survey, and it was determined that the availability of these fabrics would be an important service. The company will prepare these fabrics soiled to a standard reflectance, and the batches after proper aging are to be carefully tested. Further information about the availability of the materials can be obtained by writing the company.

Ultrasonic Generators—Central Scientific Co., 1700 Irving Park Road, Chicago, Ill. Two new models of Ultrasonic Generators. They are portable, popular priced, and generate high power. These new Ultrasonic Generators are stable, efficient, and easy to operate for physical, chemical, biological, and industrial research or control. The Ultrason generates sound wave energy in the crystal holder to vibrate semisolids, liquids, and gases. Typical uses in chemical reactions and in other applications: to activate ozone to peroxide; to remove fatty acids from semi-refined oils; to emulsify oils; to disperse pigments; to accelerate extractions; to hasten or retard growth of bacteria, mold, and enzymes.

The U-300 Ultrason crystal delivers 300 watts of sound energy to the oil bath. A maximum of 10 watts of power per square centimeter of crystal area (76 mm. crystal) is permissible without fracture of crystal. The crystal excitation circuit is energized by 900 watts supplied by a low impedance line from the voltage, high-frequency generator utilizing 115 volt, 60 cycle. This new 300 model can be used either for research, where high power is requisite, or for specific production applications. A unique development of the U-300 crystal holder is that it can be used to treat granular materials or readily adapted to process a continuous flow of liquid or

gases. Model 100 Ultrason delivers a maximum of 6 watts at the crystal This model, with its associated crystal holder, has been especially designed as a research instrument for the observance of ultrasonic effects by microscope. It produces a maximum of 6 watts of power at the crystal. Both units operate at 450 kc. and provide instant and accurate reproduction of power and frequency conditions. Designed for continuous operation and trouble-free service. Provided with built-in safety features.

New Motor-Driven Stiffness Tester—W. & L. E. Gurley, Troy, N. Y. Designed for rapid, consistent, and accurate tests on light metals, foil, paper, plastics, textiles, leather, hard rubber, fiber products, and other thin flexible sheet materials. The tester measures the stiffness, or absence of it, of practically any thin flexible sheet material, and its capacity is from light tissue paper or thin cloth up to the heaviest single sheet boxboards in common use, and it can also be used for light metal and foil testing. It has a balanced pointer which pivots in jewel bearings, and moves parallel to a sine scale mounted on the base. It can accurately show the degrees of stiffness for such products as boxboards, playing cards, bristols, bonds and ledgers, coated textile fabrics, plastics, leather, hard rubber, light, metals etc.

Miniature Multitester—International Instruments, Inc., New Haven, Conn. This instrument is a combination ohmmeter and voltmeter, for testing resistances and both a-c. and d-c. voltage frequencies. As an ohmmeter, the Multitester will test and indicate resistances from 0 to 2 million ohms, with an accuracy of ±2 per cent of linear scale. In testing voltages, it registers d-c. voltage from 0 to 300, with a claimed accuracy of ±2 per cent at 10,000 ohms per volt. A-c. voltage, registering from 0 to 10,000 ohms per volt, is stated to be accurate to within ±5 per cent. It was designed for testing electrical office equipment but it is believed that the device will be well received in radio, television and other home appliance fields, and also will be of use on production lines and in the laboratories of producers of electrical equipment of all kinds.

Temco Furnace—Thermo Electric Manufacturing Co., Dubuque, Iowa. The new series 1700 TEMCO electric furnaces employ an advantageous door arrangement. To permit access to the heating chamber with minimum loss of heat the insulated door has been divided into an upper and lower section, both sections being controlled by a single counterbalanced lever. By moving the lever from the forward position to vertical the lower section is lowered separately while the upper section remains snugly in place over the top half of the heating chamber. Other features of the furnaces include an all-steel body of welded construction, six inches of dual insulation, and heating elements of highest quality nickel-chromium alloy. The furnaces are supplied with either a TEMCOMETER temperature controlling and indicating instrument, or with an electronic controlling pyrometer. The furnace may be operated continuously up to 1650 F. and intermittently to 1900 F.

Gilmont Ultra-Microburet—The Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y. Three important improvements have recently been made in the Gilmont Ultra-Microburet, so that it now features a special swivel attachment to the micrometer which facilitates operation; a crank handle that increases speed of titration; and also an improved stand and attachments to simplify adjustments in titration. This Gilmont functions as follows: A precision ground plunger displaces mercury in a reservoir sealed off by a silicone rubber gasket contained in an aluminum bushing. The displaced mercury in turn forces a precisely determined amount of titrating solution through the fine orifice immersed in the solution being analyzed.

Improved Boston-Bradley Adjustable Blade—Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda, Md. This blade affords the technical worker a multiple tool for laying down film-forming media of any predetermined thickness. It is composed of a rectangular-shaped stainless steel bar having two blocks, one attached permanently to each end thereof. It is made from nonmagnetic stainless steel; it is available in three sizes; stainless steel construction of instrument prevents corrosion; ordinary wear does not affect accuracy, as any surface wear is compensated for when shims are employed to set blade clearance desired.

Gardner Model 105 Washability and Abrasion Machine—Henry A. Gardner Laboratory, Inc. Electrically operated, straight-line type, for paints, varnishes, lacquers, linoleum, and other products. Very useful for testing the washability of paint under controlled conditions. By the use of a new attachment, Abrasion Boat Attachment, this machine may now be adapted to wet or dry abrasion testing.

Interchemical Direct Reading Wet Film Thickness Gage—Henry A. Gardner Laboratory, Inc. A new instrument for measuring the wet film thickness of paint, varnish, lacquers, and related products. Seven various ranges are now available. The Interchemical Thickness Gage is essentially an eccentric center wheel supported by two concentric wheels. Wet film thickness within a range from 0 to 4 mils is measured by the instrument with an accuracy of 0.1 mil simply by holding the axle of the gage between the thumb and forefinger, rolling the gage over the wet film, and reading the calibrated engraved scale on the side of the outer wheel. The gage is direct reading; two readings can be made on any one specimen in only a few seconds; the instrument is simple, light in weight, and can be used immediately after application of the coating by any usual method; the cost is nominal.

Turbine Blade Fatigue Tester—The Baldwin Locomotive Works, Philadelphia 42, Pa. A new fatigue testing machine, designed to subject turbine blades and materials to fatigue loads under conditions similar to those in high-temperature turbine service, applies alternating flexure loads up to ±1350 lb to a specimen at a frequency at 3600 cycles per minute while it is held at temperatures up to 1800 F. and is under tensile loads up to 8000 lb. The machine is reported to be the first to enable fatigue tests combining the two types of loading on specimens. The machine is known as the Sonntag SF-5.

Universal Load Cell—Both tension and compression loads can be measured by means of a new SR-4 Load Cell, Type U. As in other SR-4 load cells, the pick-up elements are resistance wire strain gages which are bonded to a steel load-responsive member and hermetically sealed within a rugged cylinder. Four load capacities are available—500, 2000, 10,000, and 50,000 lb. Greater accuracy of measurement within all ranges than earlier models has been achieved by doubling the voltage output of the load cell gages. (Baldwin)

Tubing Fatigue Machine—A rotating beam fatigue machine of 1,200,000 in. lb. capacity, more than one hundred times that of the Sonntag SF-10R machine has been built by Baldwin. Reflecting a trend toward the testing of actua industrial equipment in addition to standard test specimens of materials, the new Sonntag machine will be used for fatigue testing pipe spans of two to ten feet in length and up to 8⅝ in. in diameter, under loads encountered in service. Load is applied by a calibrated spring which is compressed hydraulically by means of a hand pump. Bending loads are indicated on a removable dial in units of approximately 6.7 lb., a calibration chart being used to show their exact magnitude. (Baldwin)

Vibration Table—This table will shake loads up to 1000 lb. at 600 to 3600 cycles per minute with a simple harmonic, horizontal motion having total amplitudes up to 0.124 in. Vibration is produced by a mechanical oscillator that is rigidly attached to the table and consists of two adjustable eccentric disks rotating on vertical eccentric shafts in opposite directions. (Baldwin)

Midget Meter—International Instruments, Inc., New Haven, Conn This meter is 1 in. in diameter, with a scale arc of 270. It is being developed for special uses in aircraft applications where size and weight limitations are of prime importance. The meter is constructed to withstand vibration and shock. The instrument can be made watertight and is designed to mount by means of a threaded ring. This method of mounting eliminates the drilling of mounting-screw holes and permits sealing the meter to the panel.

New Control Cabinet for Launder-Ometers—Atlas Electric Devices Co., 361 W. Superior St., Chicago, Ill. The Launder-Ometer is now equipped with a new control cabinet for greater convenience to the operator. This cabinet is located directly behind the perheating loading table, contains all switches, pilot lights, indicating and control instruments in one compact unit. In addition it has a direct reading, 3-in. dial thermometer that serves to keep a constant and accurate check on the temperature of the water bath.

"Precision" Motor-Matic Grease Working Machine—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill. A labor-saving grease working machine used in determining the consistency of lubricating greases conforms to the latest A.S.T.M. Specifications D 217. This machine comes in a single unit, or a dual unit. The dual unit meets the needs of those laboratories making a large number of grease tests. For the laboratory making relatively few tests "Precision" has an extremely easy to manage hand-operated grease worker. This unit is equipped with a long handle for leverage and requires a minimum amount of energy in its performance.

Philosophy of Specifications[1, 2]

By L. S. Reid[3] and W. R. Willets[4]

THIS paper will not attempt to prove what kind of philosophy is employed in the development and use of specifications. It is not concerned with whether the answer is the philosophy of subjective idealism, objective realism (either rationalist or empirical) or pragmatism.

Literally, philosophy means the love of wisdom. In actual usage it is the science which investigates the facts and principles of reality and of human nature and conduct. It comprises logic, ethics, aesthetics, metaphysics, and the theory of knowledge.

That describes philosophy in general, but we also have philosophy in particular, such as the Philosophy of Art, the Philosophy of Music, the Philosophy of Science, the Philosophy of Business, and many others, including now the Philosophy of Specifications.

Just what do we mean by the "Philosophy of Specifications?" In brief, a specification may be defined as a group of maximum and minimum values of measurements of different characteristics which determine the use requirements of a given product. In setting up a specification, it is necessary that we use the elements of philosophy; for example, we must have knowledge of the product and of methods of measuring its essential characteristics; we must give due thought to the value of the specification in determining the use of the product; we must think logically at every stage of its preparation and application; and we must employ wisdom and judgment over and above the numerical data accumulated from experiment and experience. Certainly, the use of a specification as between seller and buyer involves the "facts and principles of reality, and of human nature and conduct."

In this article, we are primarily interested in specifications as applied to paper. Such specifications establish criteria for characteristics required by the end use of the paper, and all such criteria involve measurement—for example, of weight, of dimension, of strength, of optical properties, of surface characteristics, of composition, to mention a few. A specification embodies the values for one or more of such measurements, which are quantitative, and may also contain qualitative clauses such as the common: "Color, cleanliness, and formation must conform to the standard sample." When a buyer asks for a 16-lb., 50 per cent rag content paper cut to 22 by 34 in. he is, though he may not realize it, using a specification. In effect he is specifying that the paper shall contain 50 per cent of rag fiber, that 500 sheets cut to a size of 17 by 22 in. will weigh 16-lb., and that the dimensions of the paper will be as stated. He has presumably established, through experiment and experience, that such a paper will be suitable for its end use.

We occasionally encounter persons who say that they do not believe in specifications, that papermaking is still more of an art than a science. Granted that there is much art (as well as science) involved in papermaking, and that much of this art cannot find expression in a specification, there still remain many measurable properties which can find such expression. Even those papermakers who protest most vigorously against specifications for paper are very apt to be rather explicit in specifying the raw materials which they use to make the paper. Such antipathy toward paper specifications probably arises from three main factors: first, the human inertia which tends to resist changes of any sort; second, the fact that some specifications are poorly drawn up; and third, the abuse and too-rigid adherence to numerical values by those untouched by the "Philosophy of Specifications." Actually, a specification should be of the utmost value to both buyer and seller; in establishing it the buyer must first determine what he wants, and then state his requirements in explicit terms so that there can be no question in the seller's mind as to just what is wanted. Much trouble can arise from the seller's ignorance of exactly what is wanted; he may assume he is giving the buyer the desired product, but this frequently may not be the case.

There are many mutual advantages to both buyer and seller in a well thought-out and clearly drawn-up specification, and today there is practically a unanimity of opinion on the part of scientists and technically trained men in the paper industry that proper specifications are not only important, but in many cases actually essential.

Certain specifications are quite old; for many years (even before the day of machine-made paper), paper has been sold on the basis of weight and dimensions. As long ago as 1711, during the reign of Queen Anne in England, weight specifications were used because an excise tax, based on the weight of the paper, was imposed. Somewhat prior to 1894, the German Official Specifications included tensile strength requirements and resistance to rubbing. But it was not until the beginning of the twentieth century that written specifications embodying test data were initiated in the United States.

The development of paper specifications has been dependent on a large number of factors, some of which developed concurrently. To begin with, the uses to which paper was being put made it necessary to embody in such paper certain definite characteristics which were essential if the paper were to do the job required of it. One need only think of high-speed printing—new processes and inks—to realize that a paper which would have been suitable for printing in the eighteenth, or even the nineteenth, century would be unsuitable today. To determine the characteristics of paper to meet such changing conditions required the development of test methods.

As experimental work progressed and data were accumulated, it was found that certain elements in excess were deleterious to paper and that certain processes adversely affected desired properties. An example of this was the introduction of groundwood pulp in the last century; since no one then realized the impermanence of paper made using this material, there are literally thousands of volumes in libraries—volumes of important reference works—which are falling to pieces and which must be preserved for posterity by expensive means. Had a more permanent paper been specified and used for such volumes, they would have lasted in good

---

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The views expressed in this article represent the personal opinions of the authors and do not necessarily reflect those of their respective employers, nor the Societies of which they are members.

[2] Presented at the Joint Meeting of the New England District Council of A.S.T.M. and the New England Section of Technical Association of the Pulp and Paper Industry, Worcester, Mass., November 19, 1948.

[3] Assistant General Purchasing Agent, Metropolitan Life Insurance Co., Past-Chairman A.S.T.M. Committee D-6 on Paper and Paper Products and Member of TAPPI.

[4] Technical Service Laboratories, Titanium Pigment Corp., Chairman A.S.T.M. Committee D-6 on Paper and Paper Products, and Member of TAPPI.

condition for many more years. Today, when a person wants a paper for a permanent record, he can draw up a specification that will give reasonable assurance that the record will still be available many years hence, rather than crumbled away.

Experiment and experience (frequently sad and sorely gained) has led to the writing of specifications, especially by the larger and more astute users of paper. Such specifications set up limits which have been found best to describe the characteristics needed for the end use of the paper. And the end use requirements are of the utmost importance. A question is frequently put by the layman: "What's the best paper?" There is only one reply, "For what are you going to use it?" There conceivably might be the best paper on which to print a magazine, that would be entirely unsuitable for a letterhead; the best paper for wrapping a pound of steak would probably not be the most suitable for packing a pound of rice.

The requirements of any given paper, therefore, should always be kept in mind when writing a specification. Unless the buyer knows definitely what he needs and wants, it will obviously be impossible for him to set forth his requirements in a specification, and just as impossible for the seller to supply the desired product. The determination of such needs in terms of characteristics which can be clearly set up in a specification requires logical thought and effort, embracing philosophical principles. In order that there should be no misunderstanding, such requirements should be set forth in the fullest detail possible and should, whenever possible, be quantitative rather than qualitative so as not to leave a decision up to personal opinion.

There are five important requisites of a specification:

1. Accuracy and precision
2. Workability
3. Suitability
4. Flexibility
5. Acceptability

It is obvious that an inaccurate specification would be useless. It should also have the proper degree of precision. Lack of preciseness may lead to varying interpretations and argument. However, a precision beyond which there is no increase in utility or workability is unnecessary and costly, nor should precisions be called for which cannot be met by current manufacturing processes.

A specification should be workable and readily adaptable for the product specified. If it is inaccurate or inconcise, if it is written in a confused manner, or drawn up to be the epitome of perfection, it is probably unworkable. Similarly, if it requires testing methods and apparatus not readily available to the seller, it is unworkable. Occasionally a user will base a specification on a home built piece of equipment which is unstandardized and almost impossible for the seller to duplicate. Such equipment might be perfectly suitable for control purposes, but entirely unsuitable for specification purposes.

A specification should be suitable to the end use requirements and should be based on such requirements. For this reason, a "performance specification" is usually preferred to a specification setting up the composition of the material, or a specification which embodies tests which have little relation to the end use. Because of this, some paper manufacturers complain, and with some reason, that an ash specification for a paper in which all other essential properties such as strength, finish, optical characteristics, etc., are set down, may be superfluous and even harmful, limiting the free choice of the manufacturer in an unessential characteristic. Similarly, many persons feel that certain specifications (as for example the bursting strength) have no real significance in many types of paper, although such requirements are frequently included even though they have no real bearing on end use.

A specification should be as flexible as possible. Values in excess of those actually required should not be prescribed. Tolerances should be as wide as possible, compatible with end use. If a specification is too rigid, the result is apt to be increased manufacturing costs and a higher price to the buyer.

Finally, a specification must be acceptable to both buyer and seller. It should be acceptable without any reservations, expressed or implied. The best, and in most cases the only way, to assure such acceptability is to have all interested groups represented and take part in the writing of the specification. The buyer cannot be fully aware of the problems of the manufacturer nor can the manufacturer be fully aware of the end use requirements of the paper unless this is done.

The primary purposes of a specification are to inform the manufacturer just what the requirements for a specific paper are, so that he can make the paper to meet such requirements with due consideration for the costs involved and the price to be set, and to assure the buyer that he is getting the paper having the required characteristics. A specification, if properly drawn up, furnishes a common meeting ground for the supplier and buyer, and also for an independent arbiter in case unresolved disputes or misunderstandings occur.

A proper specification protects honest manufacturers and merchants from unethical competition. It prevents persons from offering products at cheaper prices lower in quality than those specified. No matter what the price, if the paper does not "come up to specifications," it will not be suitable to the buyer.

After a specification has been accurately drawn up, is workable, suitable, flexible, and acceptable to all groups, we arrive at what we consider the most important factor—its use. This involves the right interpretation of the test results, particularly if one or more is slightly below the numerical value given in the specification. It requires a philosophical approach because value-judgment should be used by the interpreter. A wide experience and intimate knowledge of the reasons in back of the numerical values set up in the specification are necessary to judge the results correctly. The interlocking of the various test values called for in the specification must be rationally deduced. The specified material should be judged on the basis of the sum of its parts; should be interpreted on the whole, and not on one particular part.

It is on this point that we find the usual abuse of specifications. If the interpreter too rigidly adheres to the numerical values, and because of insufficient knowledge or training does not have the philosophical value-judgment to arrive at the correct decision when confronted with a variation from the specification, injustice may be the result. However, the seller should not take advantage of the buyer's tolerant judgment by expecting too much leeway in not meeting the specified requirements. Here "the facts and principles of reality and of human nature and conduct" play a major rôle.

It must be always kept in mind that even the best specification is not a panacea; it cannot remedy all troubles nor cure all ills. It does, however, permit the buyer and seller both to have a better idea of what is wanted, which frequently is not the case where no specification exists. Unfortunately, even with all the various testing apparatus and methods of test now available, it is frequently impossible to correlate the results obtained by their use with actual performance. For this reason, careful study should be continuously made of the relationship between test results (as set forth in specifications) and actual end use. Even today, with the hundreds of test methods in existence, there are still many intangible characteristics of paper which cannot

be adequately determined, and efforts should be directed toward rendering these tangible and measurable. Certainties should replace uncertainties, and facts take the place of opinions.

A specification should never be considered as final nor complete. Frequently an outmoded specification will prove a greater deterrent to progress than no specification at all. Any specification should be examined periodically, in view of constantly changing conditions in manufacture and testing techniques, and in view of possible changes in end use requirements.

In conclusion: we have attempted in the foregoing discussion to show how a philosophical approach can be useful in the preparation and use of a specification. We trust we have indicated, at least, how such an approach will aid in drawing up a specification having the essential attributes of accuracy and precision, workability, suitability, flexibility, and acceptability. Furthermore, we trust that we have also demonstrated that philosophical principles can and should be applied in the interpretation and use of a specification by indicating the pitfalls that may occur if such principles are not used, either consciously or unconsciously. It might well be said that much of the discussion on the "Philosophy of Specifications" is common sense; so is true philosophy. As has often been remarked: "Nothing is so uncommon as common sense."

THE CONSTITUTION
(May 14, 1787)

These are the specifications for a ship—
Such craft as ride the roaring seas of time
Easy as gull's flight to the helmsman's grip,
Stauncher than moral tides on which they climb.
These are the master work plans, keel and wall
And rib and deck and stack and soaring spire,
Close knit as light yet mighty over-all
To ferry a people to its heart's desire.
And when there rise such storms as Ships of State
Have fled before, full rigged and all aware,
One shall go forward with its precious freight
As steady as the heart commanding there,
While snugly set each finite arch and plate
As here set forth, and riveted with prayer.

CHARLES MALAM

FROM NEW YORK HERALD TRIBUNE
MAY 14, 1948

Recent Milestones in Metals and Minerals[1]

By John D. Sullivan[2]

As ALL terms are relative I can consider the beginning of the term "recent" as almost any place in modern history. However, the principal item to be discussed tonight is current trends and developments. It would appear, however, that some historical background might be given to show the present relationship of metals and minerals to advance of civilization and to our current economic status and standard of living.

There are two elements which I propose to discuss. First, the developments of man in winning raw materials from nature and making available various metal and mineral products to satisfy human wants and, second, some of the new materials now available and the probable future trends in the immediate future.

The lack of materials to satisfy human wants is the greatest incentive man has to develop new ones. Today, we are living in a synthetic age, but we probably never would have reached our present peak in scientific development were it not for shortages of certain products. When we start to worry about running out of something, we attempt to learn how to get that something in another way or to find another material that will do the job as well. In finding the latter we usually also discover new and additional properties which extend the use—and the chain goes on. Consider petroleum to illustrate the point. We are facing a shortage of liquid petroleum in the United States, but we might already have reached it except for modern methods of mining, particularly repressuring in wells, and present refining processes which give us high yields of those fractions which are in greatest demand. Modern refining has permitted our present motor vehicle economy in the United States. However, our known petroleum reserves are limited and we are already planning to make liquid petroleum from natural gas, and we are carrying on extensive research on utilization of shales and coal for future supply.

Man must fight a continuous battle with depleting reserves. Actually we strive with nature each year for food, and each crop takes something from the soil which must be replaced eventually or we face starvation. Fortunately, we have learned how, by crop rotation and fertilizer applications, to maintain the fertility of the soil, and, in fact, to increase the yields of foodstuffs. We have learned what to add to the soil to shorten the growing and maturing periods and thus to overcome part of the battle of short seasons and early frosts in certain areas. By reforestation we are extending our wood-products reserves, and we are growing the type of trees best adapted to a given soil and climate. By organic synthesis we are making products such as methanol and thus are conserving and extending the life of forests. Although other examples could be given, the foregoing show that in the case of organic growing matter man has been able to fight off the results of depletion, and we now believe that the race can survive permanently without fear of starvation through depletion.

[1] This paper prepared by Mr. Sullivan for presentation at the joint meeting in St. Louis of the local sections of the A.S.T.M., American Society for Metals, and the Engineer's Club of St. Louis was presented, because of Mr. Sullivan's inability to attend the meeting, by his associate Mr. Bruce W. Gonser of Battelle. Mr. Gonser is very active in phases of A.S.T.M work and is Chairman of Committee B-2 on Non-Ferrous Metals and Alloys.

[2] Assistant Director, Battelle Memorial Institute, Columbus, Ohio.

While food crops can be grown in a short time, the same is not true of our mineral resources, either metallic or nonmetallic. You can grow a new crop of wheat annually, in the right environment a new crop of eucalyptus trees in four to five years, and certain types of pines in a quarter of a century, but you cannot mine iron ore, feldspar, or clay and regenerate it in a finite time.

Historical

Man has always had to struggle to live, and his existence and standards of living have been based around the materials at hand. The history of copper illustrates this. Perhaps the earliest metal used by man was copper which was found in the native state. The early man found that it was tough and malleable and that by beating it between two stones he was able to make a crude sheet. By other means he was able to form it into pots, pans, and other utensils, and the earliest practical use of copper likely was in cooking. Copper also was formed into crude tools which replaced stone. Obviously, the distribution of metallic copper was not widespread, and only a few had ready access to it. We learn, however, of early journeys to get the metal. Nevertheless, something had to be done, and man did it.

It was found, undoubtedly by accident, that certain oxidized copper minerals could be smelted in a crude shaft furnace to give a product approximating in properties the native copper. However, the vast tonnages of copper existed as sulfide and not as oxidized minerals. Man learned how to smelt sulfide ores in a blast furnace and to produce a sulfide matte which, on blowing with air, was converted to metallic copper. This, of course, multiplied many times the "reserves" of copper. Still, the blast furnace required lump ore, and the mines capable of producing direct-smelting ore soon started to become depleted. Methods of concentration were worked out, at first producing relatively coarse particles which were smelted in blast furnaces. Later, it became necessary to use finer and finer grinding, and eventually the blast furnace was judged to be inadequate and a reverberatory furnace was developed. This again multiplied by many times our "reserves." Having a reverberatory type of furnace we were able to use ores in which the copper minerals were more finely disseminated, and with the development of froth flotation in the twentieth century reserves were expanded phenomenally. We now think nothing of treating ores containing as little as 14 lb. of recoverable copper per ton (although in truth this probably would not be possible except for the gold credit). Today with heap-leaching and leaching-in-place we are recovering millions of pounds of copper annually from hitherto waste products. Man has adapted himself to his environment.

The same story as told for copper might be told for iron. Certainly our high-grade deposits of iron ore in North American are going down rapidly, but the day is fast approaching when we shall be using more and more concentrates, even the taconites and similar formation materials. Will the costs go up? Possibly, but not necessarily. Offhand one would think it should cost a lot more to produce copper from the low-grade porphyries than from the high-grade direct smelting ores of the nineteenth century. Facts do not bear this out. When you must produce cheaper in order to compete you learn how to do so by large-scale operations, by mechanical devices, by application of greater efficiency, and by utilization of better technology. Again, man adapts himself to his environment.

Metallurgy dates back to prehistoric times. Hoover's translation of Agricola's "De Re Metallica" gave approximate times when particular operations appear to have been in operation. Some of the more interesting are:

	Prior to
Gold washed from alluvial	Recorded civilization
Copper reduced from ore by smelting	Recorded civilization
Tin reduced from ore by smelting	3500 B.C.
Iron reduced from ore by smelting	3500 B.C.
Lead reduced from ore by smelting	2000 B.C. (may have been as early as 3500 B.C.)
Base metals separated from ores by water concentration	500 B.C.
Gold refined by cupellation	500 B.C.
Sulfide ores smelted for lead	500 B.C.
Mercury distilled from ore	Before Christian era
Gold recovered by amalgamation	Before Christian era
Sulfide ores melted for copper	Before Christian era
Copper refined by oxidation and poling	1200 A.D.
Manufacture of nitric acid and aqua regia	1400 A.D.
Roasting copper ores prior to smelting	1550 A.D.
Stamp mill used	1550 A.D.

The iron blast furnace was developed in the last half of the fourteenth century. The first furnace probably was in Belgium. The first large-scale smelting of iron ore in the United States was in 1664. Bessemer was granted an English patent on his steel-making process in 1856. In 1860 he built his own steel plant. The open-hearth process was invented about the same time as the Bessemer.

The first lead reverberatory smelting furnace is said to have been built in Wales in 1698. Today, of course, reverberatory lead smelting furnaces are almost obsolete, and most smelting is done in blast furnaces, but there also is substantial production of electrolytic lead.

Oersted first produced aluminum in 1825 by the reduction of aluminum chloride with potassium amalgam. Wohler later used sodium as the reducing agent. However, it was not until 1886 that Hall in the United States and Heroult in France produced aluminum by the electrolysis of the oxide in a molten fluoride bath with carbon anodes which also served as the reducing agent.

As early as 1863 magnesium was produced using sodium as a reducing agent. In 1886 the first electrolytic production was undertaken near Bremen, Germany. Apparently the first metallic magnesium produced in the United States on what can be termed a commercial scale was made in 1915 by the General Electric Co. for their own use. The American Magnesium Corp., Niagara Falls, N. Y., started production in 1917 using a process involving the electrolysis of magnesium oxide in a fused fluoride bath. Dow Chemical Co. came into operation at Midland, Mich., in 1917 with the magnesium chloride-from-brines electrolytic method, but because of a coal shortage could not operate at capacity. Between the first World War and the recent World War, Dow was the sole producer of magnesium in the United States. During World War II other companies became producers.

The art of electrolytically refining crude copper was almost simultaneous with the introduction of the dynamo about 1865. The first custom plant using this process was built in Wales in 1869. An experimental plant was operated in Pennsylvania in 1879, but the first commercial refinery was built in Newark, N. J., by Balbach in 1882–1883. The refineries at Baltimore, Md., and at Anaconda and Great Falls, Mont., were not started until 1887, 1891, and 1892, respectively. The germ of the cyanide process used to leach gold and silver ores can be found in an article published by Elsner in Germany in 1846. He apparently failed to realize the commercial significance of his chemical studies, and it was not until 1887 that the first British patent on the process was issued. The first U. S. patent was in 1889. The first plant was built in New Zealand in 1889; the first in the United States in 1891.

Statistical

The value of mineral products production in the United States in 1947 was $12,400,000,000 of which mineral fuels was the major item. The latter comprised $7,800,000,000, whereas metallic

and nonmetallic products were $3,000,000,000 and $1,600,000,000, respectively. This is a huge expansion over 1939 when the total was $4,900,000,000, even taking into consideration inflated values.

Figure 1 compares the population in the United States from 1900 to 1946 with agricultural, industrial, and mineral production. Except during war years these have virtually paralleled each other.

Table I shows the production of some major metals in the United States from 1880 to 1947. In some cases consumption is higher than production, as is true, at the present time with, for example, copper and zinc. These data show the enormous increase in metal production, which in itself indicates the technical and industrial strides which have been made, and the general increase in the standard of living in the United States.

The 1947 production capacity of sixteen major metallic and nonmetallic engineering materials is given in Table II.

TABLE II.—UNITED STATES PRODUCTION CAPACITY OF SIXTEEN MAJOR METALLIC AND NONMETALLIC ENGINEERING MATERIALS.

Material	Short Tons	Per Cent
Concrete	315 000 000	64.7
Steel	91 250 000	19.0
Lumber (excluding plywood)	50 000 000	10.0
Structural clay products	10 000 000	2.5
Glass	8 000 000	1.6
Gypsum (building)	4 000 000	0.8
Building stone	2 000 000	0.4
Copper	1 300 000	0.3
Lime (building)	1 000 000	0.2
Plywood	900 000	0.1
Synthetic rubber	900 000	0.1
Zinc	800 000	0.1
Aluminum	700 000	0.1
Lead	600 000	0.1
Plastics	300 000	<0.1
Magnesium	50 000	<0.1
Total	486 800 000	100

TABLE I.—PRODUCTION OF VARIOUS METALS IN THE UNITED STATES—1880 TO 1947.

	Production, tons				
	1880	1900	1920	1940	1947
Copper	30 240	303 059	604 531	909 084	846 389
Lead	95 725	367 773	529 657	533 967	375 267
Zinc	23 239	123 886	463 377	724 192	862 200
Steel ingots	1 397 015	11 410 928	47 188 886	66 982 686	85 000 000
Pig iron	4 295 000	15 444 000	41 357 000	47 399 000	58 295 000
Aluminum	(Began 1883)	3 575	69 021	206 280	570 000
Magnesium			62	6 261	11 000

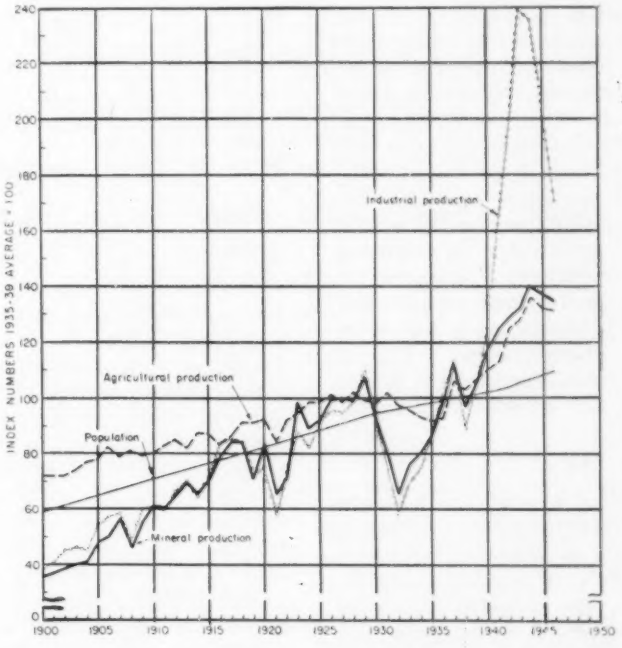


Fig. 1.—Comparison of Growth of Physical Volume of Mineral Production with That of Agricultural and Industrial Production and Population, 1900–1946.

The following indexes have been used: Volume of farm production, U. S. Department of Agriculture; mineral production, 1900–1918, Warren Persons' Forecasting Business Cycles; mineral production of 1919–1946 and industrial production, Federal Reserve Board; total population of the United States, Bureau of the Census.

Modern Trends

We are no longer willing to accept what we have, and our goal is to produce tailor-made products to serve particular uses. Up to the turn of the present century we used metals and fairly simple alloys. As our engineering needs increased we have made new and better products. We want better properties, and we also want to avoid loss and waste resulting from rust, corrosion, and other deterioration. Part of the deficiencies is made up by protective coatings but resistance to corrosion and better properties by composition is a main goal. No longer do we expect the life, for example, of steel to be as short as it was even 25 years ago. As a result, the cycle of return of scrap for reuse has slowed down. Alloys in the sense that we know them today really came into their own about the time of the first World War, and shortly thereafter. The great impetus of research and our mounting engineering production resulted in so many new and useful metals that the present status would have been staggering to the imagination 50 years ago.

High-Temperature Alloys:

High-temperature alloys have advanced far from the "stainless" steels of 30 years ago. The requirements of modern power plants are severe, and alloys have been developed to fill the needs. Supercharger-disk materials must withstand a temperature of 1100 F. under high stress. For this purpose, chromium-nickel-cobalt-iron alloy, strengthened with such other elements as molybdenum, tungsten, columbium, or titanium, is used. One ferrous alloy used for disks contains 16 per cent of chromium, 25 per cent of nickel, and 6 per cent of molybdenum. The gas-turbine blades used in superchargers and jet engines are subjected to temperatures of 1500 to 1600 F., and the metal, itself, sometimes reaches a temperature of 1500 F. To secure stability, still more highly alloyed materials must be used and some are practically iron-free. The strongest materials suitable for precision casting are the cobalt-base alloys containing 40 to 70 per cent of cobalt and such other additions as chromium and molybdenum or chromium, nickel, molybdenum, tungsten, and columbium.

Another series of alloys, based on chromium, with upward of 50 per cent of this metal, is showing great promise. An example is one that contains 60 per cent of chromium, 15 to 25 per cent of molybdenum, and the balance iron. This alloy must be melted and cast in a vacuum. In preliminary tests it shows up better than the cobalt-base alloys and gives promise of permitting safe use of still higher stresses. There is much hope also that other alloys will be forthcoming which will have better properties than the present ones. Those metals offering promise, in addition to chromium, are titanium, columbium, tantalum, molybdenum, and tungsten.

Demands, however, are even greater

than present metallic products can give. Therefore, considerable research is being done on ceramic materials for turbine parts, rocket liners, etc. Definite progress has been made. The use of relatively pure oxide systems such as those of beryllium, aluminum, magnesium and zirconium shows great promise in high-temperature application. Design, however, is also important in the use of ceramic products.

While schemes for the development of rocket and atomic-energy space ships are left for interesting speculation, active work is under way on the use of rocket engines for air-borne supersonic vehicles. Besides involving the ultimate skill in design of the engine, steering devices, and other controls, their success depends on our ability to find materials of construction to withstand temperatures hitherto considered beyond the range of engineering materials. Again, skillful design can permit lower maximum temperatures. Without cooling, temperatures of 5000 F. and higher may be reached in the engine.

Other Ferrous Alloys:

Among other outstanding advances in ferrous metallurgy is the use of minute additions of boron to steel. The potent effect of boron for increasing hardenability has been established beyond doubt. Best results are obtained with the addition of only minor amounts, on the order of 0.001 to 0.003 per cent. It has little effect on tensile properties other than through its effect on hardenability. One investigation has shown that the addition of 0.0015 to 0.003 per cent of boron can be used to replace half of the molybdenum in aluminum-killed steels of the following average base compositions:

	Per Cent
Carbon	0.30
Manganese	0.85
Nickel	0.50
Chromium	0.50
Molybdenum	0.40
and Carbon	0.30
Manganese	1.60
Molybdenum	0.40

A marked advance in vitreous enameling was the advent of titanium-bearing enamel steels. These contain only about 0.2 per cent of titanium, but they give outstanding properties, particularly with some enamels.

Light Metals

We are, however, approaching a new metal milestone, and one that will be a prime part of our future metal economy. This is partly because of properties and partly because of the raw materials supply situation. I want to stress the future probabilities of the light metals in this alloy age.

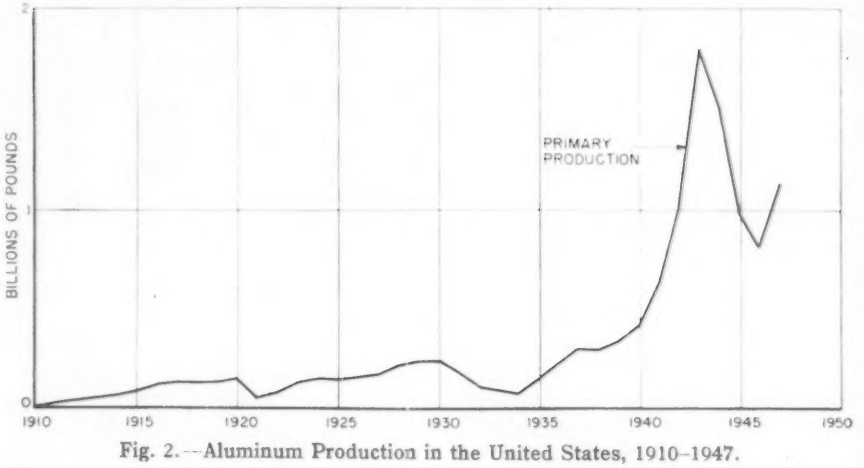


Fig. 2.—Aluminum Production in the United States, 1910–1947.

Aluminum:

Aluminum and magnesium have, of course, come into their own, particularly aluminum. Figure 2 shows the production of primary aluminum in the United States from 1910 to 1947. Today our production would be greater were it not for power shortages. More widespread knowledge of the nature and fabricating characteristics of aluminum resulted from wartime production experience. High-speed rolling mills and other modern plants were constructed to permit high production. Technique in cladding has advanced, as have spot-welding operations.

In the way of new alloys, Aluminum Company's 75S (and Reynolds' 301), a prewar development, was made available, thereby providing a light alloy with properties in some respects superior to mild steel. Its use is growing. Aluminum-magnesium-zinc alloys are also having considerable development in the casting field where good mechanical properties are obtained without heat treatment. Furthermore, such compositions are amenable to brazing because their melting temperatures are high and their properties are not adversely affected by the brazing treatment. Aluminum Company's 750 bearing alloy (6.5 per cent Sn, 1.0 per cent Ni, 1.0 per cent Cu) was introduced in 1939. XA750 bearing alloy was introduced later as a modification of 750 by the addition of 2.5 per cent of Si. Its composition is:

	Per Cent
Tin	6.5
Silicon	2.5
Copper	1.0
Nickel	0.5
Commercial Aluminum	Balance

Magnesium:

Figure 3 gives production information for magnesium from 1935 to 1947. Because of incendiary uses the wartime consumption has not been equalled in the postwar days, but because of useful properties the consumption can be expected to increase at a normal healthy rate. Before the war, although consumption was small, sand castings ran ahead of wrought products. During 1946, production was about equal, but since March, 1947, wrought products again are running behind sand castings. Die and permanent-mold castings pro-

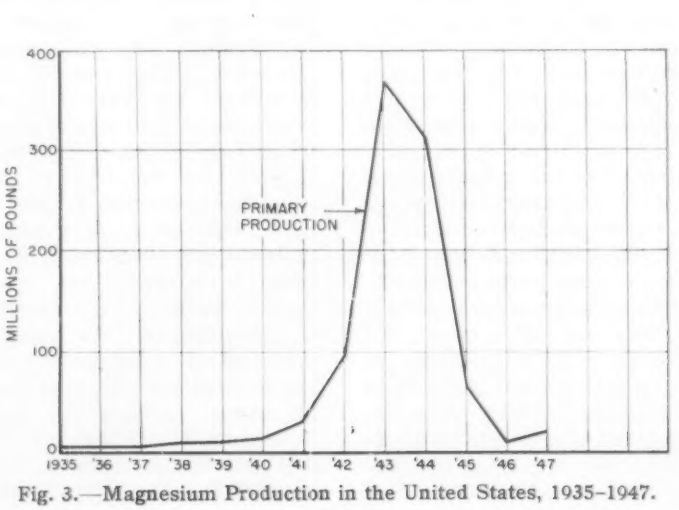


Fig. 3.—Magnesium Production in the United States, 1935–1947.

duction is smaller but relatively stationary.

A large part of the material used in sand casting is secondary magnesium. It does not have to be given a preliminary remelt as does most aluminum scrap. In fact, it would not be economical to do so. The scrap which may cost only about 3 cents per pound goes directly to the melting room, and this makes the economic position of sand castings more favorable. High-zinc (2 and 3 per cent) magnesium casting alloys used in the United States and their relative merit compared with the low-zinc (0.5 per cent) casting alloys used in Great Britain and on the Continent have been thoroughly aired. Comparisons have shown that use of the low-zinc alloys contributes greatly to improved soundness of the castings without a serious sacrifice in resistance to salt-water corrosion.

Magnesium-zinc-zirconium alloys similar to Dow ZK60 containing about 6 per cent of zinc, 0.7 per cent of zirconium and the balance magnesium have a favorable outlook, and extension of use in the United States is expected. They are characterized by high yield strength in compression. This has been one of the favorite alloys of Magnesium Elektron Ltd. in England. Considerable interest is being shown in magnesium-zirconium alloys with zinc, or silver, or both, as the principal alloying element. Such alloys are said to have higher compressive yield strength than that of current commercial alloys.

The melting methods have been changed, and grain refinement by superheating is now obsolete. Research has shown that grain refinement equivalent to that obtained by superheating may be obtained by inoculating the melt with carbon. The carbon may be introduced into the melt in a variety of ways and is effective at the usual pouring temperatures, thus eliminating the need for superheating. An especially convenient method of getting the carbon into contact with the melt is in the form of carbon tetrachloride introduced into the fluxing chlorine gas stream. The chlorine may be bubbled through the liquid carbon tetrachloride, which is maintained at a controlled temperature to permit the desired amount of carbon tetrachloride vapor to be swept into the melt. In this manner, fluxing, degassing, and grain refinement are accomplished in one effective operation and with little effort. The metal is then ready to pour and cast.

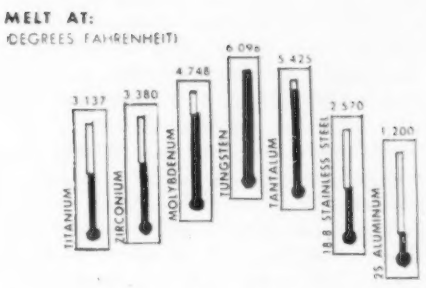


Fig. 4.
(*From Modern Industry*)

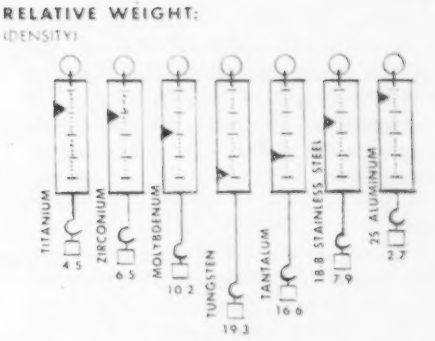


Fig. 5.
(*From Modern Industry*)

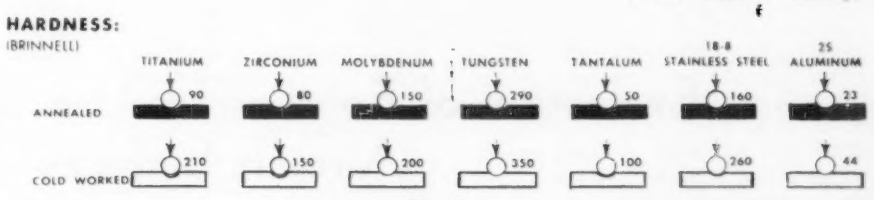


Fig. 6.
(*From Modern Industry*)

Titanium:

Metals that are bound to be more important in our future economy are titanium and zirconium. Titanium already is on the threshold of being commercially important, and it only remains for a cheaper method of production to be developed until its use will skyrocket. Pure titanium metal is relatively soft but it work hardens readily. Because of its low density its stress-volume relationship is excellent.

Figure 4 shows the melting point of titanium, zirconium, molybdenum, tungsten, tantalum, 18–8 stainless steel, and aluminum. Titanium melts at 3137 F. (1725 C.), which, of course, is well above that of iron and steel.

Figure 5 gives the relative weights or densities of the same metals. Only aluminum is lighter than titanium, which has a density of 4.5. Also, note the combination of high melting point and not too high density for zirconium. Both of these metals, but particularly titanium, offer great possibilities in airborne vehicles, particularly of the supersonic type. Based on strength-volume ratios, titanium is the highest of the group.

Figure 6 discloses the Brinell hardness of the metals in both the annealed and cold-worked states. The increased hardness with cold work is pronounced with all of the metals.

As shown in Table III, the tensile strength of cold-rolled stainless steel at 40 per cent reduction is 210,000 psi contrasted to 73,000 for ingot iron. Likewise, aluminum alloy 75S when heat treated to develop maximum strength has a tensile strength of 76,000 psi. as contrasted with 22,000 psi. for full-hard 2S (pure) aluminum metal. The strength-density ratio of 75S is 28,000 contrasted to 8200 for 2S. Thus by alloying, strength is increased. The

TABLE III.—COMPARISON OF WROUGHT TITANIUM WITH SOME OTHER METALS AND ALLOYS IN SHEET FORM.

Material	Density	Mechanical Properties				Strength-Density Ratio	
		Annealed		Cold Rolled			
		Tensile Strength, psi.	Elongation in 2 in., per cent	Tensile Strength, psi.	Elongation in 2 in., per cent	Annealed	Cold Rolled
Titanium	4.5	89 000	25	123 000 (50% reduction)	8	19 800	27 000
Aluminum (2S)	2.7	15 000	15	22 000 (full hard)	1	5 800	8 200
Aluminum alloy (75S)	2.7	32 000	14	76 000 (heat treated)	10	12 000	28 000
Magnesium (AM2S)	1.74	27 000	15	37 000 (10% reduction)	9	15 500	25 000
Magnesium alloy (A261X)	1.8	40 000	15	47 000 (10% reduction)	8	22 200	26 000
Iron (Armco)	7.87	42 000	48	73 000 (cold drawn)	12	5 300	9 300
Carbon steel (1020)	7.86	60 000	30	.....	...	7 600	....
Stainless (18–8)	7.86	150 000	60	210 000 (40% reduction)	25	19 000	27 000
Copper	8.94	30 000	55	60 000 (80% reduction)	10	3 400	6 700
Beryllium-copper (2%)	8.23	70 000	40	200 000 (heat treated)	1	8 500	24 000

same is true with titanium. While pure titanium hot-rolled at 1650 F. has a tensile strength of about 89,000 psi. one of the more interesting alloys has a tensile strength of 198,000 psi. with 2 per cent elongation, and another a tensile strength of 169,000 psi. with 11 per cent elongation.

Nonmetallics

Before closing I wish to stress again the importance of nonmetallic minerals and products in our engineering economy. Taking 1937 as a typical prewar year, total sand and gravel produced was 190,000,000 tons and that used for building was 55,000,000, while during the same year the production of steel ingots and castings was 56,000,000 net tons. Even in steel's peak war year of 1944, production was only 89,000,000 tons whereas total sand and gravel was 195,000,000 tons. The latter's peak, however, was 304,000,000 tons in 1942. The United States tonnage productive capacity of concrete is $3^1/_2$ times that of steel, and that of glass is greater than all non-ferrous metals combined.

As time goes on, civilization will continue to advance and our standard of living will increase. Man will consume more mineral products, both metallic and nonmetallic. We are now at the zenith of a metal age, which, however, will continue to broaden, grow and expand. Metals will be supplemented by nonmetallic materials and plastics, and we can safely predict that the overall consumption of mineral products will continue to grow, and that we shall in the future be supplied with products even superior to those we get today.

Evaluation of Polishes for Use on Aluminum Aircraft Surfaces[1]

By Roy A. Machlowitz[2]

Synopsis

The work reported in this paper was performed in the course of preparing a specification covering procurement of aluminum polishes for use on naval aircraft. The following test methods were employed: caking number, nonflammability, flash point, low-temperature stability, corrosiveness, abrasive number, coarse particles determination, and measurement of performance properties. Results of tests on eleven selected polishes are given. The test methods are described and their salient features are discussed.

Large quantities of polish are required for maintenance, both for reasons of appearance and increased service life, of the aluminum surfaces of naval aircraft. Governmental policy requires that procurement of materials, wherever possible, be based on specifications. The work reported in this paper was performed to furnish the basis for a specification covering aluminum polish, although some of the test methods discussed herein were not incorporated in the specification[3] which was later promulgated.

Navy Aeronautical specifications covering materials in commercial production are generally based on the properties of the available products. Samples submitted by a number of manufacturers are subjected to pertinent tests, which are based on existing methods of other Government agencies and of the A.S.T.M. The available methods are frequently modified to increase their applicability to the material under test or to amend inadequacies revealed during the test program. The range of data obtained in the tests of those polishes whose performance and other properties seem satisfactory is arbitrarily established as the minimum and maximum limits for each specification requirement. This practice, while it does not limit procurement to the one "best" material, may be justified in that it permits procurement of several satisfactory polishes of nearly equal quality under the competitive conditions preferred for Government purchases.

The test methods investigated prior to issuance of Navy Aeronautical Specification P-69a are divisible into four categories, under which they will be discussed in some detail.

Safety of the Personnel Using the Polishes:

Provisions for the safety of personnel, essential in the case of a material intended for hand use by untrained personnel, were incorporated in Specification P-69a to prohibit the use of cyanides, of most volatile chlorinated solvents, and of materials having obnoxious odors. The presence of cyanides is detected by the usual ferric chloride–ferrous sulfate test. The presence of other possibly toxic constituents is indicated by the formulation data which the manufacturer is required to submit. In case of doubt as to the toxicity of a material, the polish is thoroughly tested, including skin patch tests and other studies on animals, by the Naval Medical Research Institute, Bethesda, Md., prior to its being approved for naval use.

Storage Qualities:

The complexity and extent of naval procurement operations required that careful consideration be given to those properties which affect the storage and shipment of aluminum polish. Laboratory tests which are intended to determine (or predict) the usability of a material after prolonged storage are, at best, poorly correlated with actual storage. They may, however, help eliminate those materials least likely to withstand long-term storage. The following tests were used, although their value lies largely in insuring safety during shipment and storage rather than as indicators of usability after storage:

Caking Number Test.—Duplicate 50-ml. samples of the polish were centrifuged for one minute at 500 rpm. after which the number of gentle inversions required to loosen the cake of abrasive which formed in the tube was noted, with a maximum of 20 being acceptable. The author is in full agreement witn Messrs. Mantz, DuBois, Sinsheimer, and Clarke[4] as to the weaknesses of this test method, but no better method has as yet been

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The opinions expressed in this paper are those of the author and not necessarily official opinions of the Naval Air Experimental Station or the Navy Department.

[2] Chemist, Aeronautical Materials Laboratory, Naval Air Experimental Station, Naval Air Material Center, U. S. Naval Base Station, Philadelphia, Pa.

[3] Navy Aeronautical Specification P-69a, Amend-2—Polish; Aluminum, May 20, 1946.

[4] "Discussion of Paper on Measurement of Metal Polish Performance," ASTM Bulletin, No. 150, January, 1948, p. 49.

devised to measure the stability of polish dispersions.

Non-Flammability Test.—In this test, a 3 by 6-in. panel was coated liberally with the polish and a small flame was passed along the bottom edge of the panel. Continued burning of the polish after removal of the flame was cause for rejection.

Flash Point Test.—This is the conventional open cup test procedure with a minimum of 82 C. (180 F.) being required.

Low-Temperature Stability Test.—Duplicate samples of polish were subjected to three 2-hr. periods at −40 F. (±4 F.) with 1-hr. periods at 117 ± 2 F. intervening between the periods at −40 F. The samples were then thawed at room temperature for 16 hr. and then shaken to restore the original degree of dispersion. The thawed samples, when used to polish a tarnished panel, are required to produce reflectance readings at least 90 per cent as high as those produced on another portion of the tarnished panel by a control sample maintained at room temperature. This test simulates the changes in the polishes produced by the temperature variations occurring during storage.

Effect on Aluminum:

The following tests were used to detect any undesirable effects the polishes might have on aluminum.

Corrosiveness Test.—Triplicate aluminum-clad aluminum alloy panels were coated with the polish and placed in an atmosphere free of corrosive vapors. Half of each panel was wiped clean after 24 hr., the other half being wiped clean after 48 hr. Any evidence of discoloration or pitting is cause for rejection.

Abrasive Number Test.—This test is identical with that described by Clarke and Adams[5] and that in Navy Department Specification 51P5f except for the following modifications:

1. A definite brass alloy (Federal Specification QQ-B-611, Composition C, Rockwell B hardness of 65) is specified as it is known that the type of brass used affects the results obtained. In addition, care was taken to assure that the brass disk remained level since the convexity induced by the grinding action during the course of several determinations would reduce the area being abraded.

2. Clarke and Adams[5] used brass disks in testing liquid metal polishes intended primarily for use on brass and switched to sterling silver disks in their tests of silver polish. This example would dictate the use of aluminum-clad aluminum alloy disks in tests of polishes intended for use on that type surface. However, brass disks, rather than aluminum-clad aluminum alloy disks, were used for the following reasons: (a) greater ease of fabrication; (b) greater number of determinations possible before replacement of the disk is necessary; and (c) the relative order of the members of a series of polishes in terms of degree of abrasiveness would be exhibited independently of the particular metal used in the abrasive number determination. The measurement of the degree of abrasiveness of various metal polishes might well be standardized on the basis of the use of disks made of a specific brass alloy of a given hardness.

3. A definite billiard cloth conforming to Navy Department Specification 27C1d was used.

4. Based on the data obtained from tests conducted by the author, a maximum permissible abrasive number of 45 was established.

Coarse Particles Determination.—Users of articles fabricated of aluminum-clad aluminum alloy, particularly aircraft which are exposed to severe weather conditions, have long been concerned with the decreased resistance to corrosion resulting from the scratching of the metal surface. The possibility that such scratching might result from the presence of coarse particles of abrasive in the aluminum polishes led to an interest in determinations of coarse particle content. In accordance with conventional practice, coarse particles were regarded as those retained on No. 200 and No. 325 sieves. The abrasive material was extracted from the polishes by a series of solvent washes (acetone, benzol, water, and ether) followed by centrifuging at each stage, as in the determination of the pigment content of paints. Duplicate 5-g. samples of the dried abrasive were transferred to 400-ml. beakers; 200 ml. of distilled water containing 0.1 per cent Aerosol OT were added and the resulting mixture heated to boiling. Boiling for 1 min. was sufficient to break up small agglomerates. The suspension was then slowly poured through a "nest" consisting of a dried, weighed No. 200 sieve set into a dried, weighed No. 325 sieve, both 3 in. in diameter. The "nest" was set in a modified Buchner funnel having a rubber lining to afford an air-tight seal, with suction being supplied by a water aspirator. Any small lumps remaining on the sieves were broken up with a camel's hair brush. Washing of the material being sieved was accomplished with an ordinary laboratory wash bottle which had its capillary tip outlet replaced by a miniature shower head, 1½ in. in diameter. This modification afforded an effective multi-stream washing action. Washing was discontinued when 200 ml. of water remained clear after passing through the sieves. The sieves and the retained abrasive were dried for 1 hr. at 220 F., cooled, and weighed. It is evident from the above that the material retained on the No. 200 sieve would also have been retained on the No. 325 sieve. The values reported in Table I are "per cent abrasive passing through a No. 200 sieve but retained on a No. 325 sieve." The sum of the percentages in the two columns indicates the percentage of material coarser than No. 325 sieve.

The use of suction-aided sieving, rather than ordinary wet sieving, greatly reduced the time required for this determination. Check determinations on several samples, with and without the use of suction, showed agreement in results well within the limits of precision encountered in this type of test.

Performance Properties:

The primary concern in testing aluminum polishes is, of course, the measurement of the effectiveness of the polishes in removing tarnish and producing surfaces which exhibit high reflectance. The performance of a polish may be measured in terms of two factors, that is, the degree of specular reflectance produced and the ease with which tarnish is removed. The first three of the test methods described below are concerned with the first-mentioned factor while the fourth test method measures the efficiency of the polish in performing its tarnish removal function.

A reproducible method of tarnishing the metal surface and an objective, reproducible means of measuring the reflectance produced as a result of the removal of tarnish are essential to the measurement of polish performance. The tarnish most commonly encountered on naval aircraft is the result of ocean spray. For this reason, the test panels used in this study were tarnished by immersion in boiling synthetic sea water, the higher temperature being used to accelerate the formation of tarnish. The percentage composition of the synthetic sea water was: 2.50 sodium chloride; 1.10 magnesium chloride ($MgCl_2 \cdot 6H_2O$); 0.16 calcium chloride ($CaCl_2 \cdot 2H_2O$); 0.40 anhydrous sodium sulfate and 95.84 distilled water. The tarnish resulting from this treatment is representative of that actually encountered in service and can be produced in any laboratory. Furthermore, the tarnish is specified (see below) in terms of reflectance readings which are exact measurements.

This laboratory has found that the

[5] Frank E. Clarke and Robert C. Adams, "Measurement of Metal Polish Performance," ASTM BULLETIN, No. 147, August, 1947, p. 57.

TABLE I.—RESULTS OF TESTS OF ELEVEN SELECTED POLISHES.

Polish Sample	Toxicity	Caking Number	Non-Flammability	Flash Point	Low Temperature Stability, per cent	Corrosiveness	Abrasive No.	Coarse Particles: Per Cent Abrasive Retained on No. 200 Sieve	Coarse Particles: Per Cent Abrasive Passing Through No. 200 But Retained on No. 325 Sieve	Reflectance After Prepolishing	Restoration of Reflectance, per cent	Retention of Reflectance, per cent	Rate of Tarnish Removal: Reflectance after 50 Strokes	Rate of Tarnish Removal: Reflectance after 80 Strokes
Navy Aeronautical Spec. P-69a requirements .	Non-toxic	20 max.	Shall not continue to burn	82 C. min.	90% min.*	Non-corrosive	....	....	....	70 min.	95% min.	95% min.	65 min.	70 min.
A.....	OK	16	OK	Above 82 C.[a]	OK—92.2	OK	24	0.29	2.56	83.9	99.4	101.1	70	..
B.....	OK	2	OK	Above 82 C.	OK—93.0	OK	4	0.17	0.91	78.8	104.4	99.0	67	75
C.....	OK	5	OK	Above 82 C.	OK—98.4	OK	33	0	0	81.3	99.3	101.6	72	..
D.....	OK	3	OK	Above 82 C.	OK—100.4	OK	41	0.04	0.24	72.6	105.1	105.0	75	..
E.....	OK	4	OK	Above 82 C.	OK—108.6	OK	16	0	0	76.1	106.2	104.8	75	..
F.....	OK	6	OK	Above 82 C.	OK—100.5	OK	1	0.04	0.46	77.7	99.2	107.0	68	70
G.....	OK	3	OK	Above 82 C.	OK—109.4	OK	40	0.03	0.14	79.1	96.3	102.2	77	..
H.....	OK	0	OK	94 C.	OK—95.6	OK	3	0.05	0.04	70.6	106.4	99.0	65	75
I.....	OK	Less than 20[b]	OK	Above 82 C.	OK—100.4	OK	0	0.05	1.92	73.6	100.8	98.4	65	75
J.....	OK	6	OK	Above 82 C.	OK—108.0	OK	2	0	0.27	73.2	121.8	102.1	66	71
K.....	OK	6	OK	94 C.	OK—102.0	OK	1	4.66	10.87	91.0	102.1	101.0	70	..

[a] The material frothed or boiled above 82 C. without a flash point being observed.
[b] The disappearance of the cake could not be seen. When the tube was emptied after 20 inversions, no cake was present.

Photovolt Glossmeter, whose simplicity of operation exceeds that of the Hunter Reflectometer, affords a convenient, accurate, and objective means of measuring the reflectance of test panels. All reflectance measurements were made in accordance with Procedure A of A.S.-T.M. Method D 523 – 44 T, with the following modifications: (*a*) a black glass having a refractive index of 1.52 was used to standardize the instrument, with a value of 15.0 being arbitrarily assigned to the standard to keep the readings on scale; and (*b*) readings were taken at nine points on the test panel to obtain the average reflectance reading.

Prepolishing Test.—A solvent-cleaned 9 by 12-in. aluminum-clad aluminum alloy panel, conforming to Army-Navy Aeronautical Specification AN-A-13, having a reflectance reading, measured as indicated above, between 45 and 60, was polished in accordance with the manufacturer's instructions and the reflectance again measured. It was required that a minimum reflectance reading of 70 be attained.

Restoration of Reflectance Test.—The polished panel from the prepolishing test was tarnished to a reflectance reading of 40 to 50 by immersion in the boiling synthetic sea water. The panel was again polished as before and the reflectance read. A minimum of 95 per cent of the reading attained after the prepolishing test was required.

Retention of Reflectance Test.—The polished panel resulting from the above test was stored under corrosive-vapor-free conditions for 24 hr. The reflectance reading after that period was required to be at least 95 per cent of the previous value.

Rate of Tarnish Removal Test.—The type of apparatus used in this test was illustrated and described in the article of Clarke and Adams.[5] It was selected because of its general availability and its mechanical simulation of the action employed in hand polishing. The following procedure, conducted in duplicate, was used as a measure of the efficiency of the polishes in removing tarnish: A $3\frac{31}{32}$ by $3\frac{31}{32}$ by $\frac{1}{16}$-in. aluminum-clad aluminum alloy panel was immersed in boiling synthetic sea water until its reflectance, measured as above, was between 40 and 45. The panel was set in the recess of the polishing table of the apparatus. A piece of flannel cloth, conforming to Type I of Federal Specification CCC-F-466, 8 in. in diameter, was set in place over the inverted polishing head and secured smooth and taut with rubber bands. A 10-ml. portion of the polish, measured with a calibrated plunger device, was spread evenly over that portion of the cloth covering the contact portion of the polishing head. The polish was permitted to soak in for 1 min. and the head was touched down on the panel to insure there being sufficient polish on the panel. The apparatus was then set in motion for 50 strokes, after which the panel was wiped clean with a minimum pressure to prevent application of extraneous polishing action. The reflectance was read at two separate points in the central area of the panel. If the average reflectance was above 70, the test was considered complete. If below 70, the polishing was repeated for an additional 30 strokes, with an additional 5 ml. of polish applied to the polishing cloth. The panel was again wiped clean and its reflectance read as above. A minimum reflectance reading of 65 after the first 50 strokes and 70 after the additional 30 strokes are required. The number of strokes, particularly in the case of the additional 30, may seem overly large, but, owing to the design of the polishing apparatus, approximately 50 per cent of the strokes do not impinge on the panel at all, and many other strokes miss the central area of the panel which therefore actually receives a relatively small number of strokes.

Results of Tests.—The data obtained by conducting all the tests described above on eleven of the aluminum polishes studied in this laboratory are shown in Table I. The acceptable values have previously been indicated in the description of each test. Where applicable, the requirements of Navy Aeronautical Specification P-69a are shown at the top of each column.

Discussion of the Significance of the Test Methods and Results of Tests:

Several of the test methods merit more detailed comment than given above. The caking number test, the subject of previous discussion,[4] has several obvious defects. It favors the more viscous materials since the short (1 min.) period of centrifuging cannot duplicate the settling effect of several years storage. This brief period does not reproduce the packing effect noted in clayey abrasives which agglomerate badly. One polish containing this type

of abrasive, with a caking number of 6, which is well within the limits of acceptability, was observed, after long storage in the laboratory, to form a cake which was extremely difficult to redisperse. This sample, when tested in accordance with the method recommended by DuBois and Sinsheimer,[4] still had a caking number of 6 despite the nearly doubled rate of centrifuging. The author concurs with DuBois and Sinsheimer's conclusion that "The commercial importance of this feature (separation stability) points to the need for a more comprehensive test."

A study of the data shown in Table I, particularly that for samples D, F, and K, indicates that there is little apparent correlation of the data obtained in the abrasive number and coarse particle tests with that of the performance tests. The indication that there is little correlation of the percentage of coarse particles with the degree of abrasiveness becomes especially pointed in the case of sample K. That sample has 15.53 per cent of its abrasive coarser than the No. 325 sieve, which is 12.68 per cent higher than the next highest sample (A), and yet has an abrasive number of only 1. Obviously, the hardness of the particles, their irregularity, and the effectiveness with which they are coated by the emulsion are important factors which are not indicated by a coarse particles determination. The presence of an undue amount of scratches is readily detected by the Photovolt Glossmeter since scratches increase diffuse reflectance and lower the specular reflectance, which is the quantity being measured. In fact, one polish produced so many scratches that its use actually reduced the reflectance reading of a test panel by 40 per cent (yet its abrasive number was only 28). Furthermore, studies conducted by the Naval Air Material Center Metallurgical Laboratory have shown that superficial scratches, such as those made by a polish, have no effect on the corrosion resistance of aluminum-clad aluminum alloys. For these reasons, the coarse particles determination was not recommended for inclusion in Navy Aeronautical Specification P-69a.

The abrasive number test, measuring as it does the wearing away of metal, is of value, particularly in the case of polishes to be used on planes assigned to high ranking personnel, which are frequently polished. However, a certain degree of abrasiveness is essential to polish planes which have experienced hard usage. The problem of establishing a maximum requirement for this test is difficult to solve since it will be applied to polishes which will be used on planes of both categories cited above.

An apparent anomaly exists in the set of test results pertaining to retention of reflectance. It is difficult to account for an increase in reflectance resulting from a panel being exposed to the air for 24 hr. This laboratory has not investigated this phenomenon.

Conclusions

It is believed that the test methods discussed herein achieve their intended purpose of affording objective means of evaluating the essential properties of aluminum polishes. The test procedures are relatively simple and require only apparatus generally available in laboratories concerned with metal polishes. The procedures are, in general, more valid than the rather arbitrary method of establishing the acceptable values applied thereto. The limiting values assigned to the specification requirements are established to insure the listing of several nearly equivalent materials, rather than one "best," for procurement operations in accordance with the basic naval policy of encouraging competitive bidding among qualified suppliers. This policy necessitates an arbitrariness that may seem unwarranted from a technical aspect but is justified from the point of view of procurement.

Discussion of the Paper on Action of Chromic Acid on Zinc Coatings[1]

Messrs. C. E. Reinhard[2] and E. A. Anderson[2] (*by letter*).—While we agree that the weight losses on uncorroded samples of zinc are quite low, Mr. Swaine has not indicated a real source of potential error when the method is applied to corroded samples. In our experience, the corrosion products on zinc exposed in industrial or seacoast environment carry sufficient amounts of sulfate or chlorides to cause a substantial acceleration of the attack on zinc. Since this effect will not take place on separate blanks or controls, the error may be quite appreciable. We have attempted to minimize the error by immersing the controls in the same solution used for stripping the corrosion products. While this is helpful, it may not represent a complete correction.

We should also like to comment on the rather large weight loss observed by Mr. Swaine in his first dipping. It perhaps is not well known that all zinc samples carry a thin oxide film of appreciable weight. Since this is removed in the first dipping, it makes a substantial contribution to the weight change at this point. It has been our practice to make a preliminary dip on all control panels prior to the initial weighing in order to eliminate this factor. A further possibility in connection with this large initial weight loss is that the very small amount of sulfate present might have been consumed at this time.

Mr. D. J. Swaine (*author's closure*).—Comments are gratefully acknowledged. The adverse effect of sulfate and chloride in the "chromic acid" was realized, and hence an analysis for these anions was carried out.

With regard to the large initial weight loss, I do not feel that the zinc oxide film on the specimens would account for this, especially as my electrolytic zinc specimen was pretreated with hydrochloric acid. However, Mr. Anderson's suggestion that the small amounts of sulfate and chloride present may have caused this effect, seems very likely to be correct. I had not realized that a preliminary dip was made on control specimens, since Anderson and Reinhard's paper[3] only states that "the surfaces were carefully cleaned with ether and alcohol and the pieces were weighed prior to exposure."

[1] D. J. Swaine, "The Action of 'Chromic Acid' on Zinc Coatings," ASTM Bulletin, No. 154, October, 1948, p. 52.

[2] Research Division, New Jersey Zinc Co., Palmerton, Pa.

[3] E. A. Anderson and C. E. Reinhard, "Chemical Removal of Corrosion Products in the Determination of the Corrosion Rate of Zinc," *Proceedings*, Am. Soc. Testing Mats., Vol. 39, p. 691 (1939).

Approximate Statistical Method for Fatigue Data[1]

By R. E. Peterson[2]

VERY LITTLE use has been made of statistical methods for analysis of fatigue data, because (*a*) the number of test values seldom exceeds 20, and (*b*) these values are spread over various stress levels. If we had, say, 90 test values, 30 at each of three stress levels, statistical methods might be applied, but this has not been done and probably will not be done very often in the future.

This being the case, is there any hope of analysis of 20 to 30 values obtained in the usual way? It is thought that perhaps the following approximate method will give somewhat better information than the measured width of the usual shaded scatter band.

Basis of Method

As is well known, fatigue curves (stress *versus* number of cycles to failure) may or may not show an endurance limit (horizontal asymptote). The method to be presented herein cannot be applied to the limit portion of such a curve where some specimens fail and some do not. The method is intended for such data as do not show a limit, or for the sloped portion of endurance limit curves.

Figure 1 shows fatigue data for monel metal (1).[3] Through the data an "average" curve[4] can be drawn, such that points above the curve are balanced by corresponding points below the curve for various portions of the curve. Two persons experienced in handling this type of data and fitting "by eye" average curves independently for a given set of data will obtain almost identical results.

Let us assume that testing machine and specimen dimension errors have been reduced to a negligible amount. Then if all points were on the average curve, we could say that the material is perfectly uniform and homogeneous from specimen to specimen. As is well known engineering materials are not perfectly uniform and homogeneous. The material at the critical sections of random specimens will differ slightly from that of the "average" specimen represented by the average curve, for example slight variations in hardness could exist from one specimen to the next. We might therefore think of the different specimens as lying on slightly different *S-N* curves. For the purpose of analysis we will assume that such curves differ from the average curve by fixed percentages. Such a curve is illustrated in Fig. 1 by the dashed line drawn through the stress value of 55,000 psi. and differing from the average curve at all points by the same percentage (4.56 per cent). We will assume that we are interested in the "fatigue strength" at 500 million cycles and will consider that each point has a projected value, S', at 500 million cycles. If we tabulate S' values, we can in some cases obtain enough values to justify some attempt at analysis, where otherwise there is no possibility.[5] Actually it is not necessary to draw curves of the dashed kind shown in Fig. 1; the average curve is the only one required.

Computation Method

Suppose we illustrate with an example. For the method to be applicable, test data must be obtained under "controlled" conditions in accordance with good testing practice. The stress values of the test points of Fig. 1 are given in Table I under S.[6] The next column gives S_a, the stress value on the average curve corresponding to the same number of cycles as a test point. The next column ΔS is equal to $S - S_a$. On a percentage basis this is $(\Delta S/S_a)$ 100. These percentage values should add up to approximately zero, if not it will be necessary to reshape the curve until this requirement is met. With a little practice such adjustments are readily made.

The curve containing a test point and having a constant percentage difference from the average curve will have a value of S' at 500 million cycles where we are in this case arbitrarily assuming the "fatigue strength." $S' = [(\Delta S/S_a) + 1]S_e$. At 500 million cycles $\Delta S' = S' - S_e = S_e(\Delta S/S_a)$.

Having followed the foregoing procedure, we now have a table of S' values with a new order as shown in Table I, and it is proposed that these data be used for statistical analyses in accordance with the methods given in the A.S.T.M. Manual on Presentation of Data (2).

Two methods of handling the data will be given, a computation method and a graphical method. For the computation method, it is not necessary to obtain S' values. Regardless of which method is used, it is not necessary to tabulate $\Delta S'$.

The "arithmetic mean" $\bar{X} = \Sigma S'/n$. In this case $\bar{X} = 33{,}300$ psi. If the curve is drawn so that the $(\Delta S/S_a)100$ values equal zero, then $\bar{X}$ is equal to S_e.

The "standard deviation," σ, equals $\sqrt{\Sigma(\Delta S')^2/n}$ where n is the number of test points.

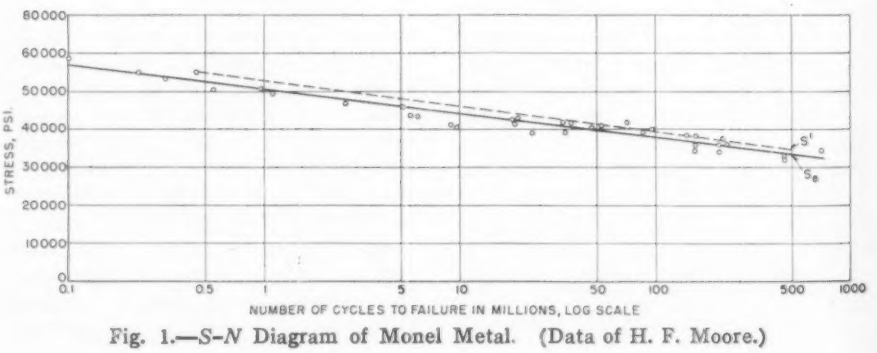


Fig. 1.—*S-N* Diagram of Monel Metal. (Data of H. F. Moore.)

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] A manuscript on this subject was circulated during 1948 with the idea that some material of this kind might be included in the forthcoming E-9 Manual on Fatigue Testing. Criticisms were such that this was deemed inadvisable. The manuscript has been rewritten largely to take account of criticisms and suggestions of A. M. Freudenthal and of several members of A.S.T.M. Committee E-11 on Quality Control of Materials. While it is desired to acknowledge the helpfulness of these men and others, it is not meant to imply that they are in agreement with this revised version. Because of the controversial nature of the subject matter, it was thought advisable to publish this write-up on a personal basis and avoid any implication of committee recommendation until the method has been thoroughly discussed and more experience with it has been obtained.

[2] Manager, Mechanics Department, Westinghouse Research Laboratories, East Pittsburgh, Pa.

[3] The boldface numbers in parentheses refer to the list of references appended to this paper.

[4] In Fig. 1 the "curve" is a straight line, but this is not always the case.

[5] Another approximate method could be based on "parallel" curves, that is, differing from each other by constant amounts, rather than by constant percentages. In the case at hand, the two assumptions lead to about the same results numerically. If we had a sufficiently large number of points so that we could work with only a small portion of the "life" scale, say from 100 to 500 million cycles, the assumption with regard to differences would matter even less.

[6] In calculating the stress it is customary to use the actual minimum section and its moment arm even when the crack occurs slightly away from this section. Strictly speaking, for statistical analysis the actual section and moment arm corresponding to the start of fracture should be used.

TABLE I.—DATA FOR MONEL METAL.

	Computation Method					Data for Graphical Method	
	S	S_a*	ΔS $(= S - S_a)$	$\frac{\Delta S}{S_a}$ (100)	$\left[\frac{\Delta S}{S_a}(100)\right]^2$	$S' = \left(\frac{\Delta S}{S_a} + 1\right) S_e$	New Order
1.....	58 500	56 000	+ 2500	+ 4.47	19.98	34 800	30
2.....	55 000	54 500	+ 500	+ 0.92	0.85	33 600	21
3.....	55 000	52 600	+ 2400	+ 4.56	20.80	34 800	29
4.....	53 300	53 700	− 400	− 0.75	0.56	33 100	16
5.....	50 900	50 700	+ 200	+ 0.39	0.15	33 400	19
6.....	50 500	52 000	− 1500	− 2.88	8.29	32 300	9
7.....	49 500	50 200	− 700	− 1.40	1.96	32 800	15
8.....	46 900	47 900	− 1000	− 2.09	4.37	32 600	11
9.....	45 900	45 900	0	0	0	33 300	17
10.....	43 900	45 600	− 1700	− 3.72	13.83	32 100	8
11.....	43 500	45 400	− 1900	− 4.19	17.55	31 900	7
12.....	43 000	42 100	+ 900	+ 2.14	4.58	34 000	24
13.....	42 500	42 400	+ 100	+ 0.24	7.06	33 400	18
14.....	42 000	40 800	+ 1200	+ 2.94	8.65	34 300	26
15.....	42 000	38 700	+ 3300	+ 8.53	72.70	36 200	36
16.....	41 500	42 200	− 700	− 1.66	2.76	32 700	14
17.....	41 500	40 500	+ 1000	+ 2.47	6.10	34 100	25
18.....	41 400	44 500	− 3100	− 6.97	48.60	31 000	2
19.....	41 000	39 500	+ 1500	+ 3.80	14.43	34 600	28
20.....	40 600	44 000	− 3400	− 7.73	59.70	30 700	1
21.....	40 500	39 900	+ 600	+ 1.50	2.25	33 800	22
22.....	40 000	37 900	+ 2100	+ 5.54	30.60	35 200	34
23.....	39 400	40 700	− 1300	− 3.19	10.19	32 300	10
24.....	39 200	38 100	+ 1100	+ 2.89	8.35	34 300	27
25.....	39 000	41 800	− 2800	− 6.70	44.90	31 100	3
26.....	38 400	36 800	+ 1600	+ 4.35	18.90	34 800	31
27.....	38 100	36 400	+ 1700	+ 4.67	21.80	34 900	32
28.....	37 400	35 500	+ 1900	+ 5.35	28.60	35 100	33
29.....	36 000	35 800	+ 200	+ 0.56	0.31	33 500	20
30.....	36 000	35 500	+ 500	+ 1.41	1.99	33 800	23
31.....	35 700	36 400	− 700	− 1.98	3.92	32 600	12
32.....	34 400	36 400	− 2000	− 5.50	30.25	31 500	4
33.....	34 300	32 400	+ 1900	+ 5.87	34.45	35 300	35
34.....	34 000	35 800	− 1800	− 5.03	25.30	31 600	5
35.....	33 000	33 600	− 600	− 1.79	3.21	32 700	13
36.....	32 000	33 600	− 1600	− 4.76	22.70	31 700	6
				+62.60	593.64		
				−60.34			
				+ 2.26			

S_e = 33 300 psi. from curve at 500 million cycles

33 300 = Avg. = $\bar{X}$

$$\sigma = \frac{S_e}{100}\sqrt{\frac{\Sigma[(\Delta S/S_a)100]^2}{n}} = 1353$$

$$v = \frac{100\sigma}{\bar{X}} = 4.06 \text{ per cent}$$

From graph (Fig. 3)
at 84 per cent 34 750
At 16 per cent 31 900
2| 2850
σ = 1425

* S_a = Average curve value for same number of cycles.

For the computation method it is convenient to use the following formula

$$\sigma = \frac{S_e}{100}\sqrt{\frac{\Sigma(\Delta S/S_a)\ 100)^2}{n}}$$

For the example given, σ comes out to be 1353 psi.

The "coefficient of variation," $v = 100\ \sigma/\bar{X}$. This coefficient gives about the same information as σ, except that it is expressed as a percentage and is dimensionless. In the case at hand, v turns out to be 4.07 per cent.

Either σ or v is a measure of the dispersion or scatter of the data, and as such is an important item of information. For ordinary purposes it is sufficient to obtain $\bar{X}$ and σ.

Significance of σ

The main use of σ is as a measure of scatter in comparing various series of data. As a consequence of Tchebycheff's theorem we can also make use of σ in the following way. Having $\bar{X}$ and σ we can say that less than 25 per cent of the points will lie outside of the range $\bar{X} \pm 2\sigma$; less than approximately 11 per cent outside the range $\bar{X} \pm 3\sigma$; and less than approximately 6 per cent outside the range $\bar{X} \pm 4\sigma$. If we have a rather small number of test points, then all points will lie within the ranges approximately as follows:

Number of Points	Approximate Range
25	$\bar{X} \pm 5\sigma$
20	$\bar{X} \pm 4.5\sigma$
16	$\bar{X} \pm 4\sigma$
12	$\bar{X} \pm 3.5\sigma$
9	$\bar{X} \pm 3\sigma$

Let us say that we have tested a group of 16 specimens and obtained $\bar{X}$ and σ. Suppose we tested 100 groups of 16 and then determined $\bar{X}'$ as the average of the $\bar{X}$ values. A question of practical interest is what the probability is that a given range for a single series will include $\bar{X}'$. Figure 2 shows that for n test points there is a probability P_s that $\bar{X}'$ will be included in a range $\bar{X}' + a\sigma$. For example if we make tests in series of 16 specimens we would expect the range $\bar{X} \pm 0.5\sigma$ would include $\bar{X}'$ in 93 cases out of 100.

In a number of recent papers (5, 6, 7, 8, 9, 10), "size effect" is considered to be a consequence of probability relations based on the "weakest link" concept. In most of these analyses σ is a criterion of the magnitude of the "size effect." In other words, it appears that research investigations which present data on a statistical basis or at least present data amenable to statistical handling are apt to find wider usage for future analysis; furthermore, it seems that $\bar{X}$ and σ are

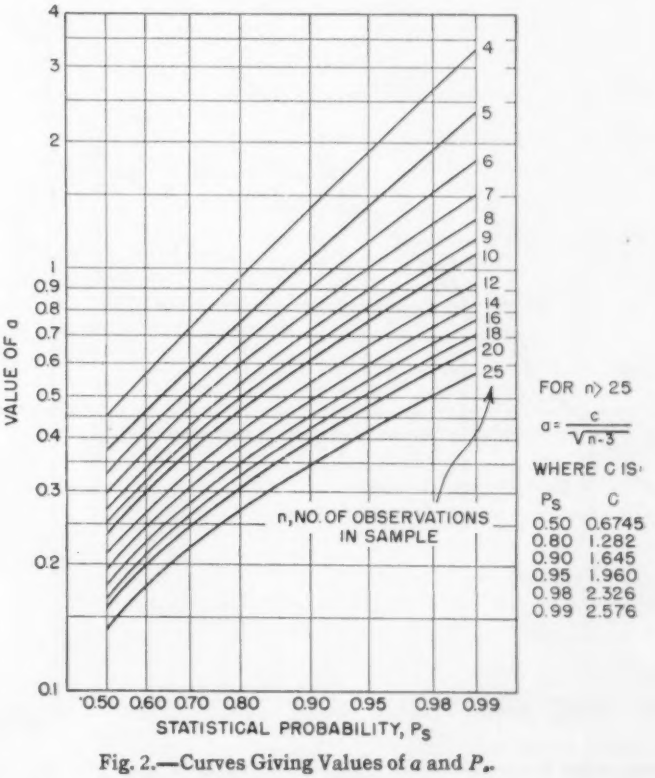


Fig. 2.—Curves Giving Values of a and P_s.

likely to be the values which will prove most useful.

Graphical Method

Instead of computing σ, a graphical method (3, 5) is preferable in some cases. Tabulate the S' values in order of increasing value. On probability paper, Fig. 3, place a stress scale on the evenly spaced side. On the "probability integral" side indicate points $1/2n$ and plot S' values at odd points $1/2n$, $3/2n$, $5/2n$, etc. (This is equivalent in Fig. 4 to dividing the ordinate scale of 1 into n layers and placing a test point on the middle line of each layer.) The ordinate represents per cent failures of the total number of specimens tested. On the probability paper, Fig. 3, fit a straight line to the points. If the fit is reasonably good, then from this line we can get:

$\bar{X}$ = S' value at 50 per cent
σ = S' value at 84 per cent minus $\bar{X}$, or $\bar{X}$ value minus S' at 16 per cent
v = 100 ($\sigma/\bar{X}$) (calculate from above)

From the graph σ = 1460 which results in v = 4.38 per cent. This agrees reasonably well with calculated values.

Figure 4 shows the appearance of the same data on ordinary graph paper, the S curve representing the probability integral of the general form

$$y = A\int_0^x e^{-Bx^2}\,dx$$

It is shown as a matter of interest only, since it is not necessary to plot this type of curve.

Remarks

It is recognized that the basic method given herewith is not a rigorous one, but it is thought that it can yield useful information. The main purpose of this write-up is to stimulate activity in the direction of applying statistical methods to fatigue problems. It is hoped that in a few years we shall have progressed to where methods, probably different from those given herein, could be issued by A.S.T.M. as recommended practices.

References

(1) H. F. Moore and T. M. Jasper, "An Investigation of the Fatigue of Metals," Univ. of Illinois Experiment Station Bulletin No. 152, p. 53 (1925).

(2) A.S.T.M. Manual on Presentation of Data, Am. Soc. Testing Mats. (1943) (Issued as separate publication.)

(3) M. G. Holmes, "An Outline of Probability and Its Uses," Burgess Publ. Co., Minneapolis, Minn. (1936).

(4) T. C. Fry, "Probability and Its Engineering Uses," Van Nostrand, New York, N. Y. (1928).

(5) W. Weibull, "A Statistical Theory of Strength of Materials," *Proceedings*, Royal Swedish Inst. Engineering Research, No. 153 (in English), Generalstabens Litografiska Anstalts Foerlag, Stockholm. (1939).

(6) F. H. Fowler, Jr., "On Fatigue Failure Under Triaxial Static and Fluctuating Stresses and a Statistical Explanation of Size Effect," *Transactions*, Am. Soc. Mechanical Engrs., Vol. 67, p. 213 (1945).

(7) A. M. Freudenthal, "The Statistical Aspect of Fatigue of Metals," *Proceedings*, Royal Soc. (London), Vol. A187, p. 416 (1946).

(8) N. Davidenkow, E. Shevandin, and F. Wittman, "The Influence of Size on the Brittle Strength of Steel," *Transactions*, Am. Soc. Mechanical Engrs. Vol. 14, p. A63 (1947).

(9) L. R. Hill and P. L. Schmidt, "Insulation Breakdown as a Function of Area," *Journal*, Am. Inst. Electrical Engrs., January, 1948.

(10) B. Epstein, "Statistical Aspects of Fracture Problems," *Journal of Applied Physics*, February, 1948. Am. Institute of Physics.

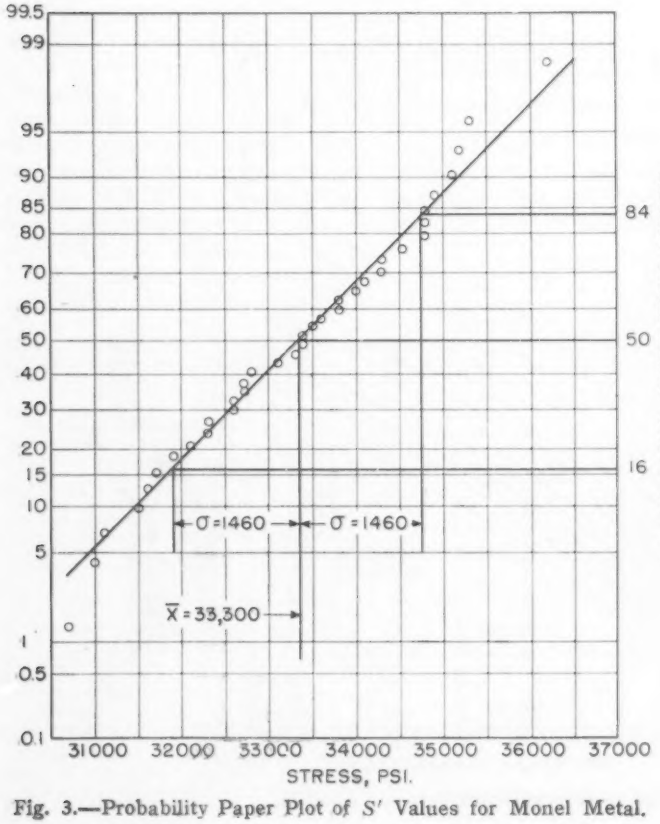


Fig. 3.—Probability Paper Plot of S' Values for Monel Metal.

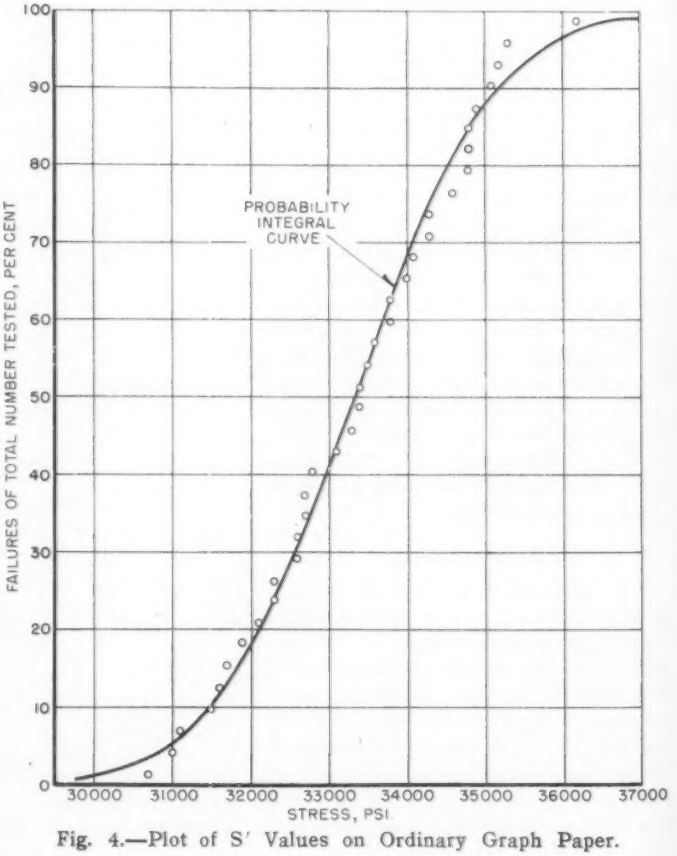


Fig. 4.—Plot of S′ Values on Ordinary Graph Paper.

A Method of Determining the Percentage Elongation at Maximum Load in the Tension Test

By Paul G. Nelson[1] and Joseph Winlock[1]

IN TESTING steel and other metals for their deep drawing properties, the strain at maximum load (usually associated with the end of uniform elongation and the beginning of "necking") gives valuable information as to the ability of the metal to accomplish, successfully, deep drawing operations in which the deformation is produced predominantly by tensile stresses, that is, as opposed to a combination of tensile and compressive stresses.

A common method (1) of recording complete load-deformation characteristics to fracture in the ordinary tension test is by plotting the load p on the test specimen *versus* the ordinary strain e which occurs in a fixed gage length of the specimen (2 in. is the most common gage length) at the corresponding load where

$$e = \frac{L - L_o}{L_o} \quad \ldots\ldots\ldots\ldots (1)$$

where:

e = ordinary strain,
L_o = original gage length, and
L = instantaneous gage length.

Diagrams of this type can either be obtained with automatic recorders or by plotting extensometer readings *versus* load readings (Fig. 1). In this type of diagram the strain e above the proportional limit is a combination of elastic and plastic strains. However, because these diagrams are made at low strain magnifications (usually not greater than 25), the presence of elastic strain is almost negligible for strains greater than 5 per cent and the strain becomes predominantly plastic. The strain e_u which occurs when maximum load is attained, is often termed uniform elongation because the strain or elongation which occurs prior to maximum load is usually substantially uniform within the gage length. At maximum load the specimen deforms locally or "necks" at some location within the gage length. With further increases in the amount of plastic strain the load drops until fracture occurs.

The above curve may also be plotted as stress $S = P/A_o$ versus strain e where A_o is the original cross-sectional area of the specimen. This gives a stress-strain instead of a load-deformation diagram. This type of curve is of the same general form as the load deformation curve but permits more satisfactory comparison of specimens with different cross-sectional areas.

Ludwik (2), MacGregor (3), and others have also plotted the load deformation characteristics of a tensile specimen in a different way (Fig. 2). They plotted so-called true stress σ *versus* the so-called "true" or natural strain ϵ

where:

σ = true stress = P/A,
P = load,
A = instantaneous minimum cross-sectional area,
A_o = original minimum cross-sectional area,
ϵ = true strain = $ln\ A_o/A$, and
ln = natural logarithm.

To obtain this type of diagram the cross-sectional areas at the minimum section are measured at various loads and the curve is plotted from the above relationships.

Using the following relations (4) (5) it is also possible to determine the "true" stress-"true" strain curve to maximum load from a load deformation curve, if the elongation within the fixed gage length is uniform prior to maximum load, if the volume remains constant, and if the slight effects of elastic strain are disregarded.

$$L_oA_o = LA \text{ and } \frac{L}{L_o} = \frac{A_o}{A} \quad \ldots\ldots\ldots (2)$$

where:

L_o = original gage length,
L = instantaneous gage length,
A_o = original cross-sectional area, and
A = instaneous cross-sectional area.

Since

$$e = \frac{L - L_o}{L_o} = \frac{L}{L_o} - 1$$

From Eq. 2

$$e = \frac{A_o}{A} - 1 \text{ and } \frac{A_o}{A} = e + 1 \quad \ldots\ldots (3)$$

Also

$$A = \frac{A_o}{1 + e} \quad \ldots\ldots\ldots\ldots (4)$$

And

$$\sigma = \frac{P}{A} = \frac{P}{A_o/(1 + e)} = \frac{P(1 + e)}{A_o} \quad \ldots (5)$$

and since

$$\epsilon = ln\left(\frac{A_o}{A}\right)$$

also from Eq. 3

$$\epsilon = ln(1 + e) \quad \ldots\ldots\ldots (6)$$

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Metallurgist and Chief Metallurgist, The Budd Co., Philadelphia, Pa.

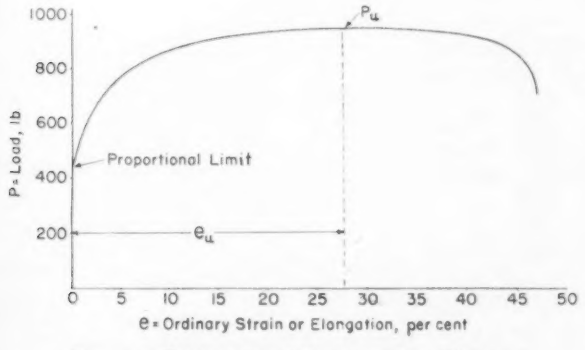


Fig. 1.—Typical Load-Deformation Diagram (0.06 per cent Carbon Sheet Steel).

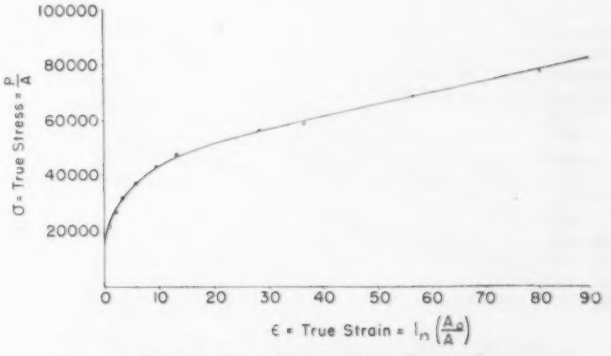


Fig. 2.—Typical True Stress-True Strain Diagram (0.06 per cent Carbon Sheet Steel).

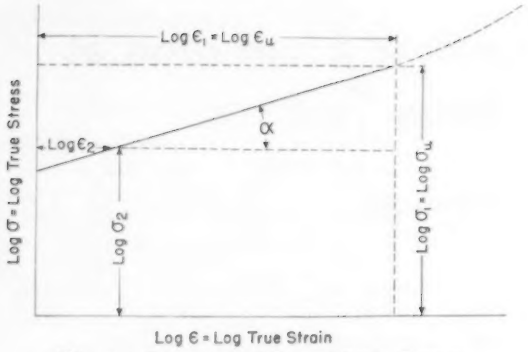


Fig. 3.—Schematical Logarithmic Stress-Strain Diagram.

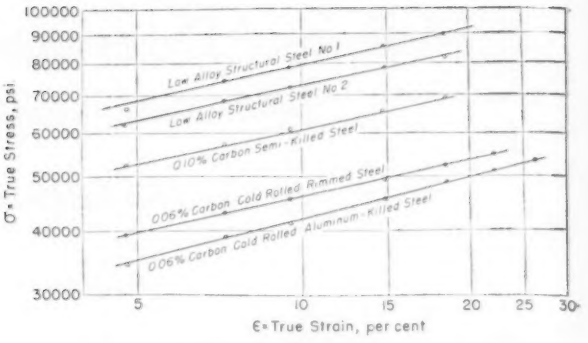


Fig. 4.—Logarithmic Stress-Strain Diagram (Typical Ferrous Steels).

The true stress-true strain curve to maximum load can, therefore, be plotted from a load deformation curve by taking points from it and plotting Eq. 5 *versus* Eq. 6. That is:

$$\frac{P(1+e)}{A_o} \text{ versus } ln(1+e)$$

Sachs (**6**) and Gensamer (**7**) and others have also shown that the maximum load, which is associated with the end of uniform elongation, occurs when:

$$\frac{d\sigma}{d\epsilon} = \sigma \quad \ldots\ldots\ldots\ldots (7)$$

where:

$\frac{d\sigma}{d\epsilon}$ = the slope of the true stress-true strain curve at at any point.

σ = true stress at corresponding point.

Sachs (**6**) also evolved a graphical method of determining the point on the true stress - true strain curve where this occurred and the true strain, ϵ_u Fig. 2, which corresponds to it. The ordinary strain e_u corresponding to ϵ_u can be determined from **6** if ϵ_u is known.

Low (**8**), Prater (**8**), Hollomon (**9**), Gensamer (**10, 11**), and others have also shown for many metals that when the true stress-true strain curve is plotted as log σ *versus* log ϵ, a straight line is obtained to maximum load (Fig. 3). From this it can be seen that the true stress-true strain curve to maximum load is a parabola of the form

$$\sigma = K\epsilon^n \quad \ldots\ldots\ldots\ldots (8)$$

where:

σ = true stress,
K = a constant,
ϵ = true strain, and
n = a constant, the slope of the straight line.

n has also been named the strain-hardening coefficient.

It should be noted that this relationship is an empirical one but considerable experimental evidence indicates that it is true for many common metals. Results of some of our tests are shown in Figs. 4 and 5.

Low (**8**) and Hollomon (**9**) have also shown by combining Eqs. 7 and 8 that for those metals which conform to Eq. 8, the true strain to maximum load ϵ_u equals the exponent n in Eq. 8. That is, *at maximum load:*

$$\frac{d\sigma}{d\epsilon} = \sigma = K\epsilon^n$$

$d\sigma/d\epsilon$ also equals $nK\epsilon^{(n-1)}$

Therefore

$$K\epsilon^n = nK\epsilon^{(n-1)} \quad \ldots\ldots\ldots (9)$$

and ϵ at maximum load $\epsilon_u = n$. Therefore, the true strain to maximum load ϵ_u equals the slope n of the log-log plot of the true stress-true strain curve.

It is possible, therefore, to obtain the ordinary strain to maximum load e_u from a load-deformation curve (Fig. 1) or the true strain to maximum load ϵ_u from a log-log plot of the true stress-true strain diagram (Fig. 3). The two values can be converted from one to the other, since $\epsilon_u = ln(1 + e_u)$ (Eq. 4). Actually, however, both methods have objectionable features. The determination of e_u from a load-deformation diagram is often difficult because the change in slope is so gradual near the maximum load for some materials as to make the determination of the exact value of the strain subject to considerable error. The value ϵ_u can be fairly accurately determined from a log-log plot of the true stress-true strain curve, but to make these diagrams it takes considerable time for testing and calculation. For thin sheet metal specimens it is especially difficult to measure cross-sectional areas, thus making it almost mandatory to construct the diagrams from load-deformation diagrams.

The method for determining e_u described below offers a simplification which we have found to be useful.

Let us consider the log-log plot of the true stress-true strain curve as shown in Fig. 3. The slope of this straight line is

$$n = \epsilon_u = \frac{\log \sigma_1 - \log \sigma_2}{\log \epsilon_1 - \log \epsilon_2} \quad \ldots\ldots (10)$$

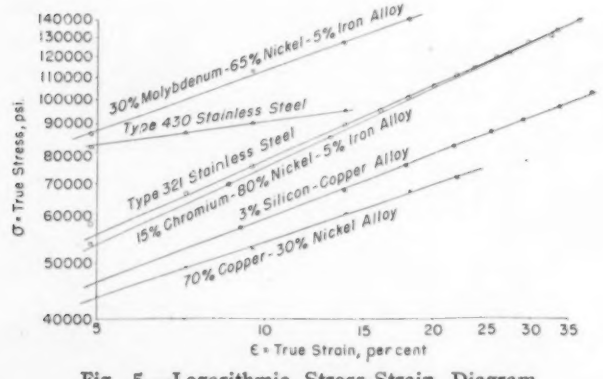


Fig. 5.—Logarithmic Stress-Strain Diagram (Non-Ferrous Alloys and Stainless Steels).

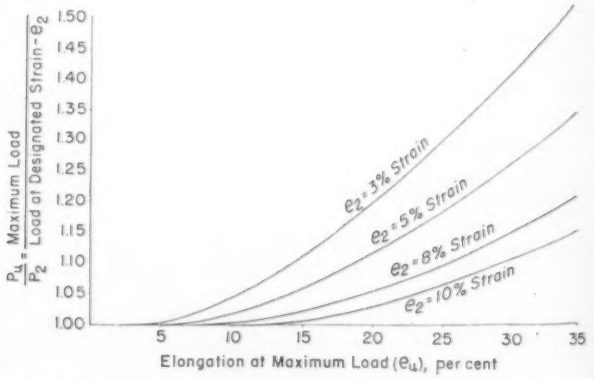


Fig. 6.—Curves Relating e_u to P_u/P_2 Ratio.

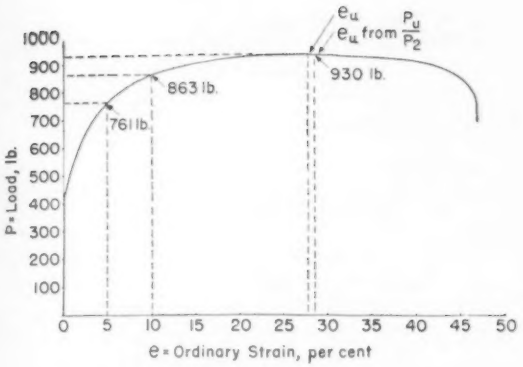


Fig. 7.—Determination of e_u (0.06 per cent Carbon Sheet Steel).

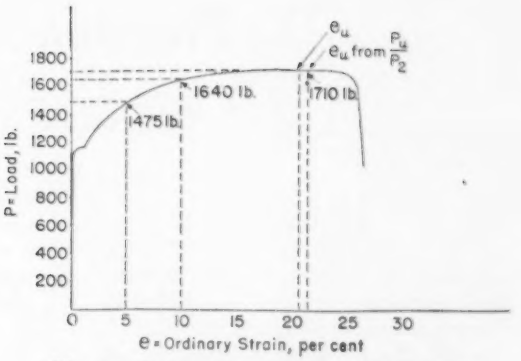


Fig. 8.—Determination of e_u (Low-Alloy Structural Steel).

where σ_1, ϵ_1 and σ_2, ϵ_2 are two points on the curve, one at maximum load and the other at a lower strain. If σ_1 is the true stress at maximum load, then ϵ_1 will be the true strain at maximum load. Then ϵ_1 equals ϵ_u, σ_1 equals σ_u and Eq. 10 becomes

$$n = \epsilon_u = \frac{\log \sigma_u - \log \sigma_2}{\log \epsilon_u - \log \epsilon_2} \quad \ldots(11)$$

$$\log \left(\frac{\sigma_u}{\sigma_2}\right) = \epsilon_u \left[\log \left(\frac{\epsilon_u}{\epsilon_2}\right)\right]$$

$$\frac{\sigma_u}{\sigma_2} = \left(\frac{\epsilon_u}{\epsilon_2}\right)^{\epsilon_u} \quad \ldots\ldots\ldots\ldots(12)$$

Eq. 12 shows that ϵ_u is proportional to the ratio of the true stress at maximum load and the true stress at some other designated strain ϵ_2. It is possible to construct curves for this equation from which, for any set value of ϵ_2 the true strain to maximum load can be determined from the σ_u/σ_2 ratio. However, because the ratio cannot be easily determined from the measurements of strain and load which are normally obtained in the tensile test; it is desirable to relate the strain at maximum load to easily measurable quantities.

From Eq. 5

$$\frac{\sigma_u}{\sigma_2} = \frac{\dfrac{P_u(1+e_u)}{A_o}}{\dfrac{P_2(1+e_2)}{A_o}} = \frac{P_u(1+e_u)}{P_2(1+e_2)} \quad \ldots(13)$$

where:

P_u = maximum load,
e_u = ordinary strain at maximum load, and
P_2 = the load at any designed strain e_2 less than e_u.

Similarly, from Eq. 6

$$\left(\frac{\epsilon_u}{\epsilon_2}\right)^{\epsilon_u} = \left[\frac{ln(1+e_u)}{ln(1+e_2)}\right]^{ln(1+e_u)} \quad \ldots(14)$$

Therefore, from Eqs. 12, 13, and 14:

$$\frac{\sigma_u}{\sigma_2} = \frac{P_u(1+e_u)}{P_2(1+e_2)} = \left(\frac{\epsilon_u}{\epsilon_2}\right)^{\epsilon_u} = \left[\frac{ln(1+e_u)}{ln(1+e_2)}\right]^{ln(1+e_u)}$$

or

$$\frac{P_u}{P_2} = \frac{1+e_2}{1+e_u}\left[\frac{ln(1+e_u)}{ln(1+e_2)}\right]^{ln\,(1+e_u)} \quad (15)$$

From this equation, curves may be constructed relating the ordinary strain at maximum load e_u to the ratio of the maximum load P_u and the load P_2 taken at some lower elongation value e_2. The lower elongation e_2 should be selected at a point well beyond any yield point elongation which may be present but at the same time as great a distance from e_u as possible. An e_2 value of 5 per cent or greater is recommended because: (1) the use of a value of e_2 of that magnitude eliminates the need for elastic strain correction; and (2) the logarithmic stress strain curves in many cases deviate considerably from straight lines at strains of less than 5 per cent. The rate of strain during the tension test should, of course, be constant from zero to maximum load. Figure 6 shows such a family of curves for values of strains e_2 of 3, 5, 8, and 10 per cent.

In order to find the elongation at maximum load, then, it is only necessary to determine the load P_2 with the aid of dividers set at a predetermined values of e_2 and the load P_u from the tension testing machine in the usual manner: or more easily, both values may be determined from an autographic load deformation curve. The ratio of these loads is then determined. The corresponding value for elongation or strain at maximum load e_u is then obtained from the curve for the particular value of e_2 for which the dividers were set.

Figures 7 and 8 are examples of the determination of e_u from the ratio of P_u/P_2 for a number of different materials. The value of e_u which was found from the P_u/P_2 ratio, is indicated on the load-deformation diagram to show the close correlation between observed values of e_u from load-deformation diagrams and the corresponding value which is determined from the P_u/P_2 ratio.

REFERENCES

(1) C. W. MacGregor, "Relations Between Stress and Reduction of Area for Tensile Tests of Metals," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Vol. 124, pp. 208–228. (1937).
(2) P. Ludwik, "Elemente der Technologischen Mechanik," Julius Springer, Berlin (1909).
(3) C. W. MacGregor, "True Stress-Strain Tension Test," *Journal of The Franklin Institute*, Vol. 238, August, 1944, pp. 111–176.
(4) E. B. Norris, "The Plastic Flow of Metals," *Bulletin*, Virginia Polytechnic Inst., Engineering Experiment Station Series, Bulletin 27 (November, 1936), p. 30.
(5) A. Nadai, "Plasticity," p. 81, Eq. 5. McGraw- Hill.
(6) G. Sachs and J. D. Lubahn, "Failure of Ductile Metals in Tension," *Transactions*, Am. Soc. Mechanical Engrs., Vol. 68, (May, 1946), pp. 271–276.
(7) M. Gensamer, "The Yield Point in Metals," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Vol. 128, pp. 104–117. (1938).
(8) J. R. Low, Jr., and T. A. Prater, "Final Report on Plastic Flow of Aluminum Aircraft Sheet under Combined Loads," Office of Scientific Research and Development, Report No. 4052, August 22, 1944.
(9) J. H. Hollomon, "Tensile Deformation," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Vol. 162 (Iron & Steel Division), pp. 268–290. (1945).
(10) M. Gensamer, W. T. Lankford, Jr., *et al.*, "The Plastic Flow of Aluminum Aircraft Sheet Under Combined Loads," National Defense Research Council Research Project N. R. C. 51.
(11) M. Gensamer, "Strength and Ductility," Campbell Memorial Lecture, Am. Soc. Metals (1946).

The Precision of Fuel Rating, 1942 to 1946

By Donald B. Brooks[1] and Robetta B. Cleaton[1]

In 1933, the Cooperative Fuel Research Committee started a monthly exchange of motor fuel samples between member Laboratories. The objectives of this exchange were to establish the precision of knock rating of motor fuels, to determine what factors affected ratings, and to assist the members of the exchange to keep their ratings in line. The Automotive Section of the National Bureau of Standards was later asked to analyze the data which had been accumulated. The results of this analysis, covering the first three years of exchange testing were published in 1936 (1).[2] Subsequent analyses were made at three-year intervals (2, 3).

A similar monthly exchange of diesel fuel samples was begun in 1938, and exchanges of aviation fuel samples for test by the Aviation and Supercharge methods were begun in 1940 and 1942, respectively. The test results on early diesel samples were analyzed by C. E. Arbuthnot (4). No previous analysis of aviation exchange results has been published.

This paper covers a total of 18,957 engine ratings of 415 fuel samples tested in the period 1942 to 1946 by the three National Exchange Groups, and by nonmember participants in certain tests. The presentation of the results of an analysis such as this necessarily involves a certain amount of uninspiring statistics.

It is desirable that the reader have a general understanding of the term "standard deviation." This is a measure of the tendency of experimental values to scatter around the average. If this scattering is "normal," two thirds of the deviations (experimental value minus average) will be less than the standard deviation. About one value in twenty will be twice the standard deviation, and one in a hundred will be 2½ times the standard deviation. Still higher values will occur with rapidly decreasing frequency; for example, only one in five hundred million will exceed six times the standard deviation. For a more complete discussion a text on statistics should be consulted (16).

Once determined, the standard deviation can be used to predict the accuracy of future tests, provided the conditions which affect accuracy are not altered. It can thus be used to determine how many measurements are required to establish a value to a desired degree of reliability. Conversely, it can be used to determine how much above the minimum acceptable quality one (or more) test results must be, to ensure obtaining material of adequate quality.

Results in Brief:

The precision of rating motor and diesel fuels decreased during the war years, but recovered during 1946. No material increase in precision of rating aviation fuels has occurred in five years, with the exception of the Supercharge rating at a fuel-air ratio of 0.095. The standard deviation now averages 0.4 octane unit for Research and Motor ratings, 2 performance number for Aviation and Supercharge (rich) ratings, and 1.4 cetane units for diesel ratings. Twice the average precision is obtained consistently by some laboratories. The precision of rating by nonmember participants is about equal to that of exchange group members.

Engine Test Methods Used:[3]

Motor fuels were rated by the Research (D 908) and Motor (D 357) methods (5). Both methods employ the bouncing pin (6) to indicate knock and are operated at the fuel-air ratio giving maximum knock. The compression ratio is varied to give standard knock intensity in both methods. In the Research method, the engine is operated at 600 rpm. and with intake air temperature of 125 F. In the Motor method, the speed is 900 rpm., and the mixture temperature is 300 F., with some changes in other conditions. The Motor method is accordingly more *severe* than the Research. The ratings of some fuels are materially lower by the Motor method than by the Research; such fuels are termed *"sensitive"*. Fuel sensitivity is defined as the Research octane number minus the Motor octane number.

Aviation fuels were rated by the Aviation (D 614) and Supercharge (D 909) methods (5). In the Aviation method, the reading of a thermal plug flush with the combustion chamber surface is used as an index of knock intensity. The compression ratio is varied to give a thermal-plug reading defined by a "match temperature" line, which is obtained empirically.

In the Supercharge method, knock

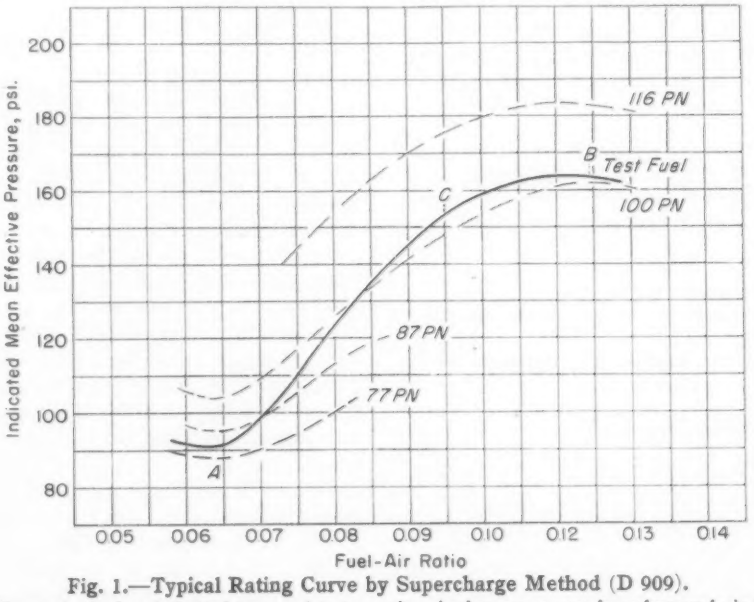


Fig. 1.—Typical Rating Curve by Supercharge Method (D 909).

Solid curve is the knock-limited imep. of test samples; broken curves are for reference fuels having ratings as given in performance number. Lean rating is made at *A*, rich rating at *B*. Rating at a fuel-ratio of 0.095 is at *C*.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] National Bureau of Standards, Washington, D. C.

[2] The boldface numbers in parentheses refer to the list of references appended to the paper.

[3] As previously published by the Cooperative Research Council the five methods were known by the following designations: Research, F-1 method; Motor, F-2 method; Aviation, F-3 method; Supercharge, F-4 method; Cetane, F-5 method.

TABLE I.—BASIC DATA OBTAINED ON R SAMPLES.

Sample	Research Method			Sensitivity	Motor Method			Tetraethyllead, ml. per gal.	Composition, per cent
	Octane No.	Standard Deviation	Greatest Error		Octane No.	Standard Deviation	Greatest Error		
R-263	73.9	0.46	0.9	6.0	67.9	0.49	0.9	0.00	80 C, 20 SR
R-264	75.4	0.48	1.2	3.9	71.5	0.38	0.8	0.75	55 C, 45 SR
R-265	88.4	0.27	0.7	8.7	79.7	0.55	1.3	2.17	85 C, 15 SR
R-266	82.5	0.31	0.7	7.7	74.8	0.41	0.9	0.00	C
R-267	82.6	0.42	0.9	7.2	75.4	0.39	1.0	1.60	SR
R-268	76.4	0.67	1.6	0.8	75.8	0.32	0.7	2.85	C
R-269	78.0	0.30	0.7	8.2	69.8	0.38	0.8	0.00	C
R-270	77.1	0.27	0.4	5.2	71.9	0.45	1.1	0.50	C and SR
R-271	84.2	0.38	0.9	6.3	77.9	0.38	0.7	1.71	Ref. and SR
R-272	79.8	0.57	1.4	1.6	78.2	0.38	1.0	0.00	Secondary reference
R-273	93.3	0.59	1.4	1.5	91.8	0.97	2.5	3.00	Secondary reference
R-274	79.2	0.30	0.5	7.2	72.0	0.27	0.6	0.60	50 TC, 50 SR
R-275	78.5	0.31	0.7	7.4	71.1	0.64	1.5	0.00	100 C
R-276	77.4	0.51	1.1	4.7	72.7	0.44	0.8	Not spec.	C and SR
R-277	83.9	0.67	1.3	5.9	78.0	0.56	1.1	Not spec.	C and SR
R-278	75.5	0.66	1.5	3.8	71.7	0.82	1.0	1.00	60 C, 40 SR
R-279	93.7	0.67	1.5	8.9	84.8	0.61	1.4	0.00	40.5 C-12, 4.5 A-6, 55 Benzene
R-280	70.9	0.62	1.2	0.0	70.9	0.50	1.1	1.26	SR and C
R-281	74.0	0.39	0.6	3.7	70.3	0.33	0.9	0.00	C and SR
R-282	83.6	0.30	0.6	1.5	82.1	0.30	0.8	2.61	80 SR, 20 natural
R-283	81.7	0.42	0.8	10.8	70.9	0.67	1.6	0.00	100 C
R-284	87.2	0.14	0.3	2.8	84.4	0.19	0.4	0.00	100 SR
R-285	79.4	0.37	0.6	2.7	76.7	0.43	1.2	2.23	15 C, 85 SR
R-286	91.6	0.62	1.0	11.6	80.0	0.59	1.4	2.86	80 X-2, 20 M-3
R-287	85.6	0.36	0.8	5.2	80.4	0.28	0.7	1.72	70 C, 30 SR
R-288	75.7	0.35	0.8	3.4	72.3	0.48	1.2	1.00	59.5 C, 25.5 SR, 15 natural
R-289	67.5	0.38	0.7	1.7	65.8	0.51	1.0	0.00	SR
R-290	75.7	0.66	1.2	6.4	69.3	0.51	1.1	0.00	TC and SR
R-291	87.3	0.42	0.7	7.5	79.8	0.28	0.5	3.00	TC and SR
R-292	80.5	0.31	0.7	1.6	78.9	0.42	1.1	0.00	78 aviation base, 22 hydrocodimer
R-293	99.4	0.56	1.1	0.8	98.6	0.60	1.1	3.97	42 SR, 30 alk, 10 Cu, 18 IP
R-294	78.1	0.56	0.9	5.9	72.2	0.70	1.4	4.02[a]	75 C, 25 SR
R-295	93.6	0.51	1.1	2.6	91.0	0.62	1.3	3.60	80 SR, 20 IP
R-296	77.6	0.63	0.9	3.2	74.4	0.79	1.4	0.44	40 aromatic, 60 natural
R-297	77.2	0.48	0.9	4.8	72.4	0.58	1.3	1.41	20.1 CC, 79.9 SR
R-298	89.4	0.41	1.0	8.0	81.4	0.38	0.6	0.00	CC
R-299	79.1	0.38	0.6	−0.3	79.4	0.49	1.1	1.37	SR
R-300	90.6	0.42	1.0	11.4	79.2	0.51	1.3	0.00	80 X-2, 20 M-4
R-301	91.0	0.41	0.7	0.6	90.4	0.23	0.5	4.43	4 N, 81 SR, 15 IP
R-302	77.5	0.88	1.9	1.9	75.6	0.38	0.9	2.19	15 C, 18 SR
R-303	95.2	0.26	1.0	12.2	83.0	0.63	1.5	0.00[a]	CC
R-304	76.3	0.46	1.2	6.6	69.7	0.52	1.0	0.00	C
R-305	98.7	0.66	1.0	16.0	82.7	0.65	1.2	0.00	P
R-306	80.6	0.57	0.9	4.3	76.3	0.42	0.8	2.00	64.3 TC, 12 hydroformate 14 N, 9.7 natural
R-307	86.7	0.34	0.7	11.4	75.3	0.49	1.4	0.00	100 polyform
R-308	90.0	0.17	0.2	11.3	78.7	0.65	1.7	0.00	50 C, 50 X-2
R-309	73.3	0.37	0.8	3.7	69.6	0.47	1.1	0.77[b]	50 C, 50 SR
R-310	77.0	0.62	1.2	6.7	70.3	0.56	1.4	0.00[a]	100 TCN
R-311	83.2	0.56	1.1	7.6	75.6	0.53	1.2	2.14	81 distillate, 11 butane, 8 pentane
R-312	86.5	0.12	0.2	2.4	84.1	0.22	0.8	0.00	62 HC, 38 SR
R-313	88.4	0.85	2.2	8.2	80.2	0.37	1.1	0.00	TC
R-314	95.1	0.73	2.0	9.7	85.4	0.36	0.8	0.00	35 X-3, 30 F-5, 15 A-6 Benzene
R-315	94.8	1.00	2.9	11.9	82.9	0.67	1.6	3.17[a]	100 Ref.
R-316	94.9	0.25	0.6	10.6	84.3	0.57	1.4	2.94	70 C, 30 Pentanes
R-317	83.4	0.37	0.6	3.8	79.6	0.38	0.8	2.78	75 TC, 25 SR
R-318	87.5	0.38	0.7	8.1	79.4	0.58	1.5	1.97	85 TC, 15 SR
R-319	74.5	1.15	1.6	5.2	69.3	0.74	1.4	0.33	50 TC, 15 CCN, 35 SR
R-320	83.8	0.62	1.5	3.9	79.9	0.32	0.7	2.81	67 TC, 33 SR
R-321	72.7	0.71	1.3	3.1	69.6	0.76	2.6	0.94[b]	50 SR
R-322	88.4	0.27	0.5	7.6	80.8	0.31	0.6	0.00	CC
R-322A	85.0	0.59	0.9	4.7	80.3	0.39	0.9	3.04[b]	Polyformed, CC and SR
R-323	89.1	0.55	1.1	11.8	77.3	0.52	1.3	0.00	C & T Ref., 10 Toluene,
R-324	88.9	0.32	0.6	9.6	79.3	0.28	0.5	3.30	TC
R-325	84.9	0.43	1.1	6.3	78.6	0.36	0.8	1.40	52 TC, 48 N, Pent. and Butane
R-326	93.2	0.48	0.9	10.5	82.7	0.46	0.8	1.93	33 Ref. N, 33 CC & P 34 N, Pent. & Butane
R-327	79.3	0.43	0.9	2.4	76.9	0.43	1.3	0.00	23.3 F-6, 76.7 C-13
R-328	82.9	0.39	0.9	0.9	82.0	0.30	0.6	0.00	42.5 alkylate, 37.5 HC, 20 SRN
R-329	87.3	0.49	1.2	4.4	82.9	0.47	1.2	2.29	SRN
R-330	86.2	0.40	1.0	7.1	79.1	0.39	0.8	3.06	TC and SR
R-331	79.6	0.43	1.1	7.1	72.5	0.47	0.9	0.00	TC
R-332	84.6	0.44	1.3	5.6	79.0	0.39	0.9	1.94	Commerical gasoline
R-333	83.0	0.39	0.7	6.6	76.4	0.45	0.9	0.00	SR and CC
R-334	81.1	0.38	0.9	6.4	74.7	0.38	0.8	0.94	45 TC, 15 CC, 40 SR
R-335	83.5	0.58	1.7	5.5	78.0	0.49	1.2	1.76	40 C, 30 SR, 22 CH, 8 alkylate
R-336	84.6	0.44	1.0	6.1	78.5	0.41	0.8	0.34	CC and SR
R-337	81.6	0.59	1.3	8.3	73.3	0.47	0.9	0.00	50 Cat. Ref., 50 C
R-338	77.9	0.34	0.6	4.4	73.5	0.35	0.8	1.15	45 TC, 55 SR
R-339	78.6	0.53	1.0	4.8	73.8	0.44	1.1	1.50	Unknown
R-340	85.6	0.30	0.6	7.3	78.3	0.33	0.7	1.57	40 TC, 60 SR

[a] Determined by one laboratory.
[b] Average of two laboratories.

intensity is judged by ear. Observations of power at a standard "trace" knock are made at a series of fuel-air ratios from full lean (0.055) to about 0.12. The engine is operated at a fixed compression ratio of 7:1. The supercharge pressure is varied to give standard knock intensity for each fuel-air ratio used. A typical rating curve is shown in Fig. 1. The supercharge lean rating (CFR F-4, now obsolete) was made at the lean minimum of the knock-limited power curve, point A in Fig. 1. The supercharge rich rating (D 909) is made at the peak of the curve, point B.

A rating is also made at a fuel-air ratio of 0.095, point C, which is close to the take-off mixture strength in full-scale engines.

Diesel fuels are rated by the cetane method (D 613) (5). A combustion indicator is employed, and the compression ratio is varied to give a standard ignition delay with the test fuel.

The primary reference fuels used for the Research, Motor, Aviation, and Supercharge methods are *n*-heptane and *iso*octane (2,2,4-trimethylpentane), and tetraethyllead in *iso*octane. Ratings of aviation fuels are commonly expressed in performance number, and for high-rating fuels in Detonation Index (7). The primary reference fuels for the cetane method are *n*-cetane and α-methylnaphthalene.

Motor Fuels

Ratings of Exchange Samples:

The basic data obtained in the exchange tests on motor fuel samples R-263 to R-340 are given in Table I. The column headed "Sensitivity" gives the difference between the Research and the Motor octane numbers. The tetraethyllead content given for each fuel is the average of the values reported by laboratories making this test. The fuel content is given as stated by the supplier of the sample.

The variety of fuel components, as shown by Table I, is too great to permit an accurate estimate of the precision of rating any one type. A study of the data indicates straight-run fuels to be rated most precisely. Fuels containing over 25 per cent cracked gasoline are rated with about 20 per cent larger error. Standardization fuels show about 40 per cent larger rating error than straight-run gasolines.

The uniformity of some exchange samples has been questioned. This possibility, in suspect cases, has been tested by examining Research and Motor ratings by laboratories making both tests. If the sample as distributed is not uniform, both Research and Motor ratings on a sample should be high in some cases and low in others. By suitable analysis, it is possible to ascertain whether such behavior is present to a greater degree than might result from the normal errors of knock testing. The uniformity of sample R-273 was thereby shown to be open to question. Incidentally, the lead analyses on this sample ranged from 2.44 to 4.10 ml. per gallon. Some slight doubt also exists as to the uniformity of sample R-333 as distributed to nonmember participants in the semi-annual exchange tests. Sample R-333 as sent to exchange group members, however, ap-

TABLE II.—DISTRIBUTION OF DEVIATIONS.

Year	Number of Ratings	Standard Deviations	Percentage of Total Number of Deviations in Range			
			0 to 0.9	1.0 to 1.9	2.0 to 2.9	3.0 and over
Research Method						
1939	1258	0.50	94.0	5.6	0.2	0.08
1940		0.45				
1941		0.44				
1942A[a]	120	0.47	...	...	...	...
1942B[a]	164	0.60	...	...	...	...
1942	284	0.55	93.3	5.6	1.1	0.0
1943	134	0.60	93.3	5.2	1.5	0.0
1944	116	0.65	90.5	6.9	1.7	0.9
1945	137	0.59	92.0	6.5	1.5	0 0
1946	214	0.45	94.4	5.6	0.0	0.0
Motor Method						
1933-35	1882	0.63	86.9	11.9	1.1	0.1
1936-38	2493	0.52	92.5	7.3	0.2	0.04
1939-41	2291	0.48	92.9	6.9	0.1	0.0
1942A[a]	168	0.42	...	...	...	...
1942B[a]	256	0.59	...	...	...	...
1942	424	0.53	93.4	6.1	0.2	0.2
1943	261	0.55	87.7	11.5	0.0	0.8
1944	262	0.51	93.1	6.9	0.0	0.0
1945	281	0.50	94.7	5.0	0.4	0.0
1946	276	0.42	98.2	1.8	0.0	0.0

[a] 1924A is first quarter of 1942. 1942B is last three quarters of 1942.

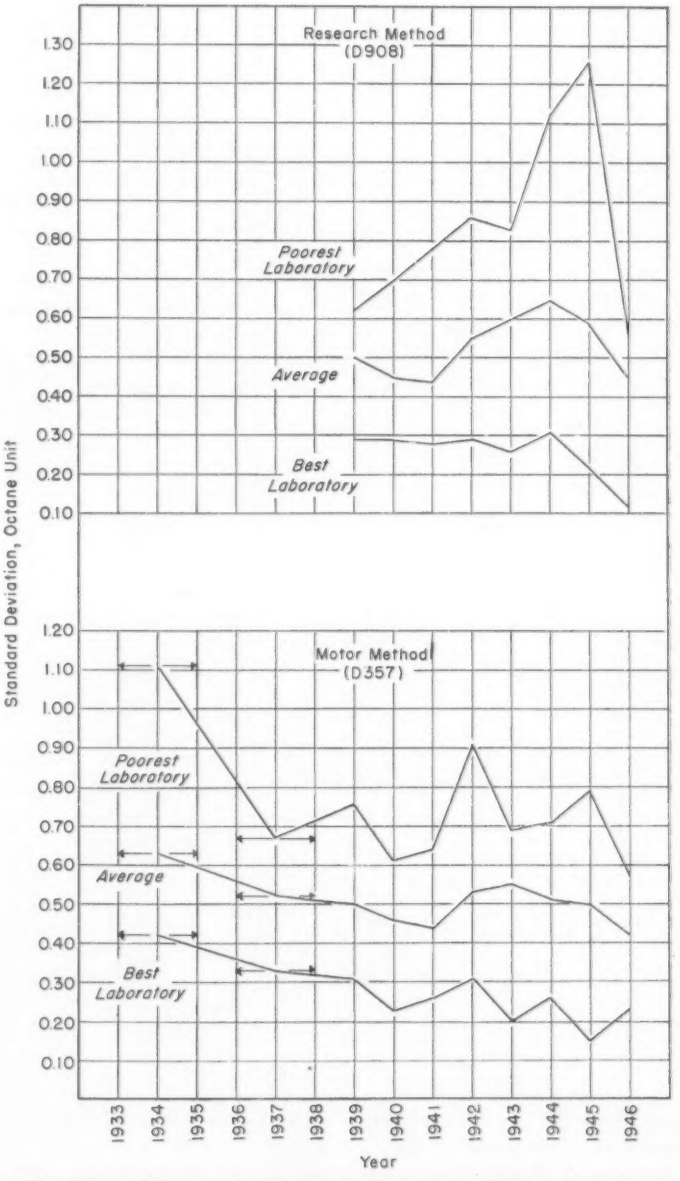


Fig. 2.—Precision of Ratings by Research (D 908) and Motor (D 357) Methods.
The average, poorest, and best values of the standard deviation of rating by Exchange Group members are shown for each year. Deterioration of precision during the war is evident for both methods.

pears to have been uniform. (While the same gasoline is shipped to all participants, the 20 samples to members would usually come out of one barrel, and some of the samples for nonmembers out of other barrels.)

Precision of Rating:

The steady improvement in the average precision of Motor ratings, evident in each of the earlier surveys (**1**, **2**, **3**), was abruptly halted by the war. Table II shows the precision and the distribution of deviations as found in past and in the present analyses. The year 1946 is noteworthy as the first year in which no deviations as large as 2 octane units have occurred by either test method.

As shown in Fig. 2, the average precision for the Motor method was 0.63 octane unit for the period 1933 to 1935, and 0.44 in 1941. Within the next two years, the average error by the Motor method was 20 per cent greater. By the Research method, the increase in error was nearly 50 per cent. During 1946, the precision by each method was about equal to that in 1941, being 0.447 octane unit for the Research and 0.417 for the Motor method.

Figure 2 also shows the highest and the lowest precision obtained for each year by members of the Exchange Groups. The highest precision is of interest as an index of the maximum precision attainable with present equipment. In the analysis of the 1933 to 1935 data (1), the maximum precision then attainable was calculated to be equal to a standard deviation of 0.37 octane unit. In the 1936 to 1938 analysis (2) a figure of 0.36 octane unit was similarly found. In the analysis for 1939 to 1941 (3), it was estimated that a precision of 0.2 would eventually be attained by both Research and Motor methods. It now appears that this figure was not optimistic, as it has been bettered once by each method. A standard deviation of 0.15 octane unit may soon be attainable by those who are willing to take the necessary pains with equipment and technique.

How to Use the Precision Measures:

The accepted measure of the precision of results is the standard deviation. Before this measure can be used with complete abandon, however, it must be known that the test results are normally distributed, that is, that the proportion of large errors to small errors, and of positive errors to negative errors, falls within certain limits. This is evident from a study of Tables XI and XII. It shall suffice to say here that the Motor ratings are normally distributed, and that the Research ratings would

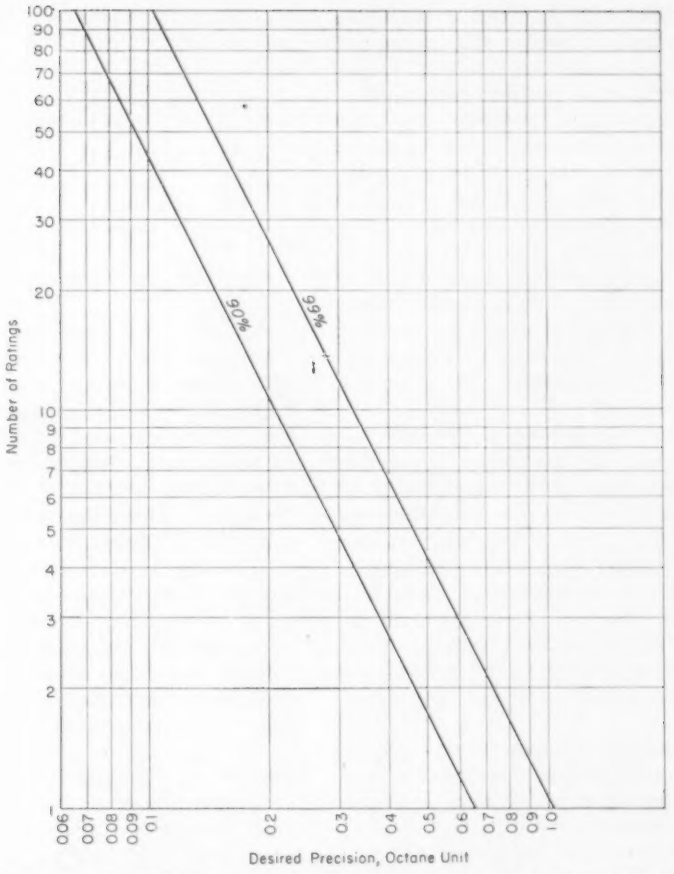


Fig. 3.—Number of Ratings Required to Yield an Average Having a Desired Precision by Research (D 908) and Motor (D 357) Methods.

The number of ratings indicated by the lower line gives a 90 per cent probability that their average will be within the desired amount of the true value. The upper line similarly gives a 99 per cent probability. Double the numbers on the "desired precision" scale and use the lower line to get a 99.9 per cent probability.

be also, were it not for the presence of three or four large negative errors. It may further be said that, except for a tendency toward skewness, the standard deviations by each method have fairly normal distribution. Thus we may proceed to draw deductions from these data.

A standard deviation of half an octane unit means that about 20 out of the next 30 ratings made under similar conditions will differ from the truth by half an octane unit. One or two of the remainder will be off by a full unit, but the chance of any rating being off by 2 units is quite small.

The average of two or more ratings will usually be closer to the true value than a single rating. Figure 3 shows the number of ratings required to yield an average having a desired precision. The number of ratings indicated by the two lines give 90 and 99 per cent probability that their average is within the desired amount of the true value. The figure was computed from an assumed standard deviation of 0.4 octane unit, a value which should be pretty close to the facts for both the Research and the Motor methods for the next year or two.

Figure 3 shows the reliability of the Motor and Research ratings. Suppose you have 4 ratings on an unfamiliar fuel. How far away from the true value is your average? The lower line in the figure shows that your average has a 90 per cent probability of being within one third octane unit of the truth. If you will not settle for 9 out of 10, the upper line shows that you have 99 chances out of 100 of being within about half an octane unit of the true value. If you are determined to have a sure thing, double the values on the precision scale. By using the lower line, you then have only one chance in a thousand that the true value will be further from your average than the amount shown on the doubled scale; in this case, two thirds of an octane unit.

Two things should be kept in mind in using Fig. 3. The figure applies only for independent observations. Experience has shown repeatedly that if the engine operator knows (or thinks he knows) what value he should get, he gets it. On samples stated to be of a certain octane number, the standard deviation of exchange tests drops to about 0.1 octane unit instead of the

customary 0.4. A blind test made later on the same sample will restore the standard deviation to its usual value.

Secondly, other pertinent information has the effect of additional ratings. In refinery control testing, for example, it would not be necessary to run four independent ratings each day to be sure of the octane number of a product to within a half unit. Yesterday's ratings, and the ratings on components, together with knowledge of their blending relations, all contribute to the precision of the answer. To repeat, the figure applies to independent ratings on an unfamiliar fuel.

Laboratories having a precision of rating differing materially from 0.4 octane unit can readily adapt Fig. 3 to their use by suitably changing the precision scale. If your laboratory is one of those exalted ones whose precision is nearer 0.2 unit, divide the values on this scale by two. If your precision is nearer 0.6, increase them by 50 per cent. But if you are around 0.8, possibly it would be better to forget the whole affair.

An analysis was made of the data in Table I to ascertain whether the precision of rating varied with either octane number or sensitivity.

It was found that the precision of rating by the Research method did not vary appreciably with either, while the precision of rating by the Motor method showed a very slight tendency to improve at higher octane-number levels.

Nonmember Participation Tests:

In the five years covered by this report, there has been a total of 811 nonmember participations in the semi-annual motor fuel exchange, which is open to all owners of ASTM-CFR engines. Approximately five sixths of the participants have reported results in time for inclusion in the final report on the samples. Table III lists the standard deviations by both test methods for members and nonmembers for each year. The nonmembers have a slightly better record by the Research method, while the National Exchange members have a definitely better record by the Motor method. These samples appear to have been representative in so far as precision is concerned, as the average precision of the member laboratories by both Research and Motor methods is within a few per cent of their average for all samples rated during the five year period.

TABLE III.—PRECISION OF RATING SEMI-ANNUAL SAMPLES.[a]

Year	Members		Nonmember Participants	
	Research Method	Motor Method	Research Method	Motor Method
1942	0.57	0.50	0.46	0.75
1943	0.50	0.45	0.47	0.59
1944	0.49	0.51	0.51	0.69
1945	0.69	0.55	0.66	0.71
1946	0.42	0.41	0.55	0.56
Root mean square average	0.54	0.49	0.53	0.66

[a] Four samples were rated each year.

Aviation Fuels

Ratings of Exchange Samples:

Prior to July, 1945, the CFR Aviation Exchange Group operated in two sections. The Aviation Section rated samples of the "A" sequence by the Motor and Aviation methods. The Supercharge Section rated samples of the "B" sequence by the Motor, Aviation, and Supercharge methods. After the consolidation of these sections on July 1, 1945, the samples carried only the "A" designation.

In rating samples near 100 octane number, some results above, and some below 100 will be obtained. The results below 100 are expressed in octane number, and those above in milliliters of tetraethyllead per gallon of *iso*-octane. Averaging and analyzing data in different units is not feasible. For this reason, all data on aviation fuels have been converted to "AN performance number." In the performance number scale, 70 is equal to 88 octane number, 100 is 100 octane number, and 115 is equal to *iso*octane plus 0.5 ml. of tetraethyllead per gallon.

Ratings and standard deviations of samples A-74 to A-152, and B-1 through B-40 are given in Table IV. Originally, Supercharge ratings were made only at the rich peak. From sample B-11 on, the rating at a fuel-air ratio of 0.095 was also evaluated. Ratings at the lean minimum of the Supercharge knock-limited power curve were obtained on samples B-18 through B-32. The reproducibility of this Supercharge lean rating was very poor, as the standard deviation averaged 6.5 performance number. It was found that the Supercharge lean rating was very close to the Aviation rating for all fuels tested by the Exchange Group. In the range 80 to 120 performance number, the Supercharge lean rating can be calculated from an Aviation rating of the fuel with *three times* the precision with which it can be measured directly. In performance number, the Aviation rating is equal to 98 per cent of the Supercharge lean rating.

The Supercharge rich ratings (D 909) of sample A-130 were so strikingly diverse that a special analysis of the ratings was made. No evidence of nonuniformity in the sample was found. Three laboratories reported results considerably below any of the 24 others. Omission of these results normalizes the distribution of ratings, reduces the standard deviation from 4.9 to 2.5 performance number, and raises the average value from 129.0 to 130.4 performance number.

The Supercharge ratings of sample A-148 were beyond the limit of the performance number scale, which is not usable above 161. These ratings and their standard deviations are therefore given in terms of the Detonation Index scale (7) which is indefinitely extensible. Detonation Index values near 160 bear approximately a one-to-one relation to performance number. The standard deviations shown in Table IV for sample A-148 may thus be compared directly with the deviations given in performance number for the other samples.

Precision of Rating:

Analysis of the data given in Table IV shows that the precision of the Motor and Aviation ratings varies with the performance number of the fuels. By both methods, the standard deviation is about 2 per cent of the rating in performance number. In preparing Fig. 4, therefore, precision has been expressed in percentage of the rating.

Figure 4 shows that there has been no consistent change in the precision of rating by the Aviation method. Some of the laboratories rate samples with a standard deviation of about 1 per cent. The lowest precision (upper line) obtained during each year by an Exchange Group laboratory has deteriorated steadily.

The precision of the Supercharge ratings at a fuel-air ratio of 0.095 and that of those at the rich peak have no tendency to vary with the rating of the fuel. In Fig. 5, little evidence of improvement in the precision of the Supercharge rich ratings is visible. The data from the ratings at a fuel-air ratio of 0.095 leave no doubt that the precision of this rating is increasing steadily. At the present rate, it should equal that of the rich rating within a year or two. As indicated by the precision of the best laboratories, however, higher precision is probably attainable at the rich peak than at 0.095.

With a view to improving quality

TABLE IV.—AVERAGE RATING DATA ON AVIATION GASOLINE SAMPLES IN TERMS OF PERFORMANCE NUMBER.

Sample	Motor Method		Aviation Method		Supercharge Method					
					Lean		Fuel–Air Ratio = 0.095		Rich	
	Rating	Standard Deviation	Rating	Standard Deviation	Rating	Standard Deviation	Rating	Standard Deviation	Rating	Standard Deviation
A-74	100.2	0.6	101.4	1.7	...	...	...	...	...	...
A-75	101.2	1.2	100.5	1.7	...	...	...	...	...	...
A-76	102.1	1.1	103.5	2.1	...	...	...	...	...	...
A-77	112.2	1.7	112.7	3.0	...	...	...	...	...	...
A-78	126.6	3.9	123.5	3.3	...	...	...	...	...	...
A-79	127.1	3.4	124.7	2.3	...	...	...	...	...	...
A-80	110.4	1.9	111.0	2.1	...	...	...	...	...	...
A-81	98.9	0.8	101.7	1.0	...	...	...	...	...	...
A-82	98.9	0.7	98.9	2.6	...	...	...	...	...	...
A-83	98.8	3.2	100.8	1.9	...	...	...	...	...	...
A-84	96.5	1.8	100.6	0.9	...	...	...	...	...	...
A-85	74.0	1.1	76.9	1.6	...	...	...	...	...	...
A-86	74.8	1.0	77.8	1.8	...	...	...	...	...	...
A-87	72.4	1.0	75.3	1.6	...	...	...	...	122.6	3.1
B-1	93.1	...	...	...	...	...	...	...	138.0	1.3
A-88/B-2	101.7	1.5	104.7	1.9	...	...	...	...	...	...
A-88A/B-2A	109.2	2.1	109.8	1.4	...	...	...	...	139.5	1.5
A-89/B-3	99.2	1.5	101.8	1.4	...	...	...	...	122.2	3.2
A-90	97.4	2.1	99.1	1.2	...	...	...	...	...	...
B-4	101.9	1.0	...	...	...	...	...	...	128.4	2.1
A-91	93.8	2.4	97.7	2.1	...	...	...	...	...	...
B-5	94.9	...	...	...	...	...	...	...	129.3	2.0
A-92	97.6	0.9	99.5	1.0	...	...	...	...	...	...
B-6	95.5	...	...	...	...	...	...	...	115.7	3.0
A-93/B-7	72.2	1.0	74.4	1.5	...	...	...	...	100.1	2.3
A-94	93.4	1.7	96.7	1.6	...	...	...	...	...	...
B-8	95.2	...	...	...	...	...	...	...	131.0	1.2
A-95	99.0	2.3	100.3	1.3	...	...	...	...	...	...
B-9	98.7	...	...	...	...	...	...	...	130.2	1.0
A-96/B-10	101.7	1.4	101.7	1.3	...	...	...	...	134.6	2.0
A-97/B-11	104.3	2.0	103.5	1.7	...	...	133.2	2.5	132.9	1.7
A-98	73.4	1.1	76.8	1.4	...	...	...	...	...	...
B-12	98.2	...	100.5	...	...	...	131.0	2.9	131.6	1.5
A-99/B-13	98.6	1.7	100.0	1.1	...	...	130.5	3.4	130.7	1.4
A-100	67.6	0.9	69.7	1.5	...	...	...	...	...	...
B-14	96.0	...	101.6	...	...	...	128.2	3.6	129.0	2.1
A-101/B-15	98.1	2.4	100.3	1.3	...	...	127.0	3.1	127.4	1.7
A-102/B-16	84.9	1.6	91.1	2.8	...	...	121.2	5.0	127.9	2.0
A-103/B-17	94.0	2.4	96.3	1.7	...	...	122.7	5.7	131.0	1.9
A-104/B-18	99.0	1.6	100.4	1.6	104.5	3.9	129.2	3.1	130.0	1.3
A-105/B-19	91.1	1.6	94.9	2.0	98.9	7.6	114.6	2.2	116.5	1.7
A-106/B-20	96.4	2.1	100.5	1.1	101.6	7.2	129.9	3.1	132.1	1.9
A-107/B-21	94.9	1.7	98.4	2.3	97.6	6.6	129.8	3.4	132.3	2.2
A-108/B-22	95.3	2.7	99.5	1.2	99.3	6.7	127.0	2.4	129.2	1.7
A-109	93.4	2.4	98.6	1.6	...	...	...	...	...	...
B-23	75.2	1.1	78.5	1.6	83.4	6.9	101.5	2.7	99.3	1.8
A-110/B-24	93.4	2.5	98.9	1.2	98.4	6.7	123.7	3.6	126.8	2.2
A-111	117.1	5.8	115.6	2.5	...	...	...	...	...	...
B-25	116.8	6.7	116.2	2.9	120.3	7.0	140.7	2.8	140.9	2.1
A-112/B-26	92.1	2.6	97.8	2.1	98.3	5.4	126.2	3.9	129.0	3.0
A-113/B-27	91.0	2.0	91.6	2.9	95.0	6.6	121.9	5.4	126.2	3.7
A-113A/B-27A	114.6	1.2	112.6	1.7	116.5	6.3	143.4	4.2	145.0	3.4
A-114/B-28	96.8	2.3	99.7	2.6	101.0	8.2	127.2	2.5	129.2	1.4
A-114A/B-28A	116.8	2.9	114.0	1.9	116.6	5.4	140.8	2.6	140.8	2.3
A-115	118.7	2.5	117.7	2.6	...	...	...	...	...	...
B-29	112.4	1.2	111.3	1.8	113.1	5.2	142.8	4.7	145.0	1.8
A-116/B-30	100.1	1.9	100.3	0.8	100.2	4.2	127.6	2.4	130.2	1.1
A-117/B-31	100.0	1.8	102.1	1.2	102.0	5.8	132.6	2.2	133.1	2.5
A-118/B-32	120.8	2.6	116.6	2.4	121.7	7.5	143.6	2.5	144.9	1.5
A-119/B-33	99.9	2.7	101.2	1.0	98.4	...	131.4	3.0	132.0	1.9
A-120/B-34	115.9	2.3	114.5	1.8	113.2	...	144.2	1.4	144.1	1.5
A-121/B-35	113.9	3.5	117.7	2.4	114.0	...	140.9	2.4	142.1	2.0
A-122/B-36	96.8	1.9	99.5	1.8	99.1	...	127.2	3.4	130.5	1.2
A-123/B-37	117.2	2.3	115.5	2.0	113.8	...	133.8	2.0	133.0	1.9
A-124/B-38	94.9	2.3	99.0	1.7	104.7	...	126.6	4.2	129.8	1.5
A-125/B-39	96.2	2.1	97.7	2.4	96.0	...	132.0	4.0	136.9	2.5
A-126/B-40	116.0	3.0	115.0	1.9	113.4	...	134.7	1.8	134.2	1.7
A-127	80.3	1.3	85.0	1.8	...	...	109.2	3.9	111.6	2.3
A-128	94.3	2.2	98.4	2.5	...	...	122.2	4.6	125.7	2.7
A-129	123.4	4.7	120.1	3.0	...	...	140.8	2.1	140.2	1.6
A-130	80.5	1.6	86.3	2.5	...	...	117.1	6.1	129.0	4.9
A-131	72.2	0.9	75.8	1.7	...	...	93.4	3.0	91.5	1.7
A-132	109.9	1.5	108.9	2.2	...	...	135.8	2.8	135.0	2.2
A-133	101.3	0.9	101.3	1.6	...	...	132.6	3.0	133.7	2.2
A-134	94.5	3.5	98.9	2.5	...	...	132.2	4.5	134.7	3.0
A-135	99.0	2.0	102.3	1.5	...	...	132.0	2.3	131.7	1.4
A-136	104.9	1.2	103.9	1.8	...	...	139.1	2.8	143.2	2.2
A-137	99.3	1.7	101.0	1.7	...	...	128.6	4.2	130.6	1.6
A-138	73.6	0.8	75.4	1.6	...	...	95.5	1.7	92.7	1.5
A-139	78.1	1.3	80.9	1.9	...	...	100.0	2.1	97.8	2.2
A-140	94.6	2.9	99.5	1.6	...	...	128.8	2.3	131.0	1.8
A-141	98.1	2.8	100.2	1.8	...	...	126.4	3.5	128.4	1.8
A-142	75.1	1.1	76.7	1.2	...	...	92.8	2.1	90.6	1.0
A-143	98.6	2.1	100.6	1.5	...	...	127.3	4.3	131.7	2.3
A-144	116.1	1.8	114.4	1.9	...	...	141.0	1.7	140.4	1.5
A-145	119.6	3.0	118.3	3.2	...	...	149.4	2.4	150.6	3.1
A-146	129.3	3.3	129.4	3.7	...	...	132.4	2.5	132.6	2.3
A-147	132.7	3.5	129.7	4.9	...	...	158.7	2.2	160.7	0.9
A-148	136.2	5.3	132.1	5.7	...	...	(163.5)[a]	(4.0)[a]	(168.7)[a]	(4.8)[a]
A-149	75.0	1.3	77.0	1.6	...	...	98.3	2.1	96.3	1.7
A-150	100.7	0.9	101.7	1.6	...	...	127.4	2.1	129.6	0.9
A-151	123.3	4.1	119.6	2.7	...	...	145.1	2.2	145.7	1.6
A-152	106.0	1.5	105.6	1.4	...	...	130.1	2.1	129.9	1.3

[a] Values in parentheses are given in Detonation Index.

control of aviation fuels produced during the war, the Aviation Exchange Group permitted nonmembers to participate regularly in rating the monthly samples. In 1946 this participation was limited to a semi-annual basis, as is done in the other National Exchange Groups. The comparative precision of the nonmembers is shown in Table V. The nonmembers have thus outclassed the members for the past two years, in precision by the Aviation method, and have made a very commendable showing by the Supercharge method. The poor value of 1.49 results largely

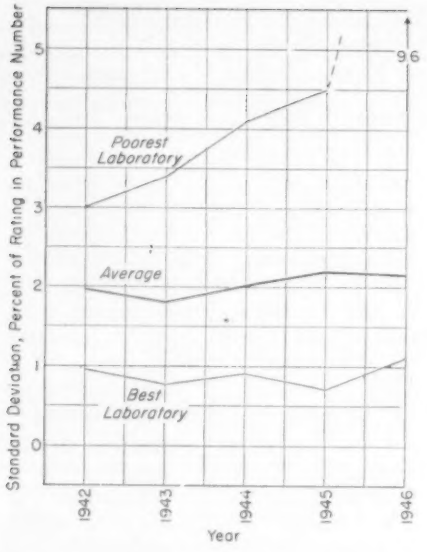


Fig. 4.—Precision of Ratings by Aviation Method (D 614).

The average, poorest, and best values of the standard deviation of rating by Exchange Group members are shown for each year. As the precision of rating varies with performance number of fuels, the precision is expressed in per cent of performance number rating.

from two highly erroneous results.

During the war, much importance was attached to determining and improving the precision of rating aviation fuels. The reliability of the precision figures given in the restricted CFR report "The Precision of Rating Aviation Fuels" (10), was debated at length. Some held that the standard deviations given were larger than those which would prevail for control laboratories. Others felt that the figures were too low, as the size of the fuel samples was such as to permit multiple ratings.

To resolve this point, special sets of "Aviation Precision Samples" were prepared and circulated. The endeavor was made to supply samples to every laboratory operating Aviation or Supercharge engines in the United States or Canada. One-quart samples designated AP-1, AP-2, and AP-3 were sent to Aviation engine owners, and 1-gal. samples designated AP-4, AP-5, and AP-6 were sent to Supercharge engine owners. Over 85 per cent of the laboratories receiving samples reported their results.

From these tests on relatively small samples, precluding multiple ratings, it was concluded that the precision measures given in the earlier Exchange Group report (10) was of general applicability, and could be used with confidence for ratings made by industry in general. A good demonstration of these facts is given in Table VI, copied from the report on the precision-sample tests (11). The second column gives the number of deviations of each magnitude which would be expected in the Supercharge ratings of the precision samples, calculated from the data given in the earlier exchange group report (10). The third column gives the number actually occurring in the Supercharge tests of the precision samples.

TABLE V.—RATIO OF STANDARD DEVIATION OF NONMEMBERS TO THAT OF MEMBERS, ON SAME SAMPLES.

Method	1942 to 1944	1945	1946
Aviation	1.21	0.98	0.79
Supercharge at 0.095	1.13	1.02	1.49
Supercharge Rich	1.12	1.05	1.07

TABLE VI.—CALCULATED OBSERVED DEVIATIONS.

Deviations in Performance Number of Less Than	Calculated from Triennial Report	Observed in These Tests
1	87	84
2	162	174
3	210	215
4	234	235
5	245	242
6	248	246
7	249	246
8	249	249

TABLE VII.—RATINGS AND TETRAETHYLLEAD DETERMINATIONS ON SAMPLE A-146

	Motor Method[a]	Aviation Method[a]	Supercharge Method at 0.095	Supercharge Method, Rich	Tetraethyllead, ml. per gal.
Average	1.25	1.25	1.45	1.46	1.45
Standard deviation	0.21	0.23	0.18	0.18	0.13
Maximum	1.51	1.57	1.90	1.89	1.73
Minimum	0.73	0.53	0.94	0.96	1.12
Standard deviation in performance number	3.2	3.7	3.3	3.7	...

[a] Tetraethyllead in certified *iso*octane, practically equal to tetraethyllead in *S* reference fuel.

Especial interest attaches to the ratings of sample A-146. This sample was prepared by adding tetraethyllead to *S* reference fuel. The ratings of the sample could therefore be affected only by momentary errors of control and errors of observation. The results obtained are listed in Table VII, in terms of tetraethyllead in the reference fuels.

This table shows that not only can there be substantial deviations from the true value in the case of individual ratings, but that averages of a comparatively large number of ratings, by the Motor or Aviation methods, may also be appreciably in error. This case, be it also remembered, is a comparison of fuels of identical composition, thereby eliminating some sources of error. The last column strongly implies that improvement is needed in the method for determination of tetraethyllead in gasoline. The engines are only a little more inaccurate than the chemists.

One of the Aviation Precision samples also was *S* reference fuel plus tetraethyllead. Supercharge ratings by 83 laboratories varied from 0.55 to 2.00 ml. of tetraethyllead per gallon of *S* reference fuel, averaging 1.48 with a standard deviation of 0.20. The supplier stated the composition as *S* plus 1.475 ml. of tetraethyllead per gallon. The precision on this sample thus was comparable to that of the Supercharge ratings on A-146.

How to Use the Precision Measures:

Unlike the Research, Motor, and Cetane ratings, those by the Aviation method are definitely not normally distributed. Those who like to take their statistics neat may glean this fact from Table XIII. Care must therefore be exercised in drawing deductions from the precision measures for the Aviation method ratings. This can be seen from Table VIII, which gives the calculated and actual distribution of deviations for the ratings made in 1946.

The considerable differences between the calculated and the observed distributions of deviations make it obvious that estimates of precision based on the normal distribution must be used with reservations. Large errors will be more frequent than is predicted by a normal

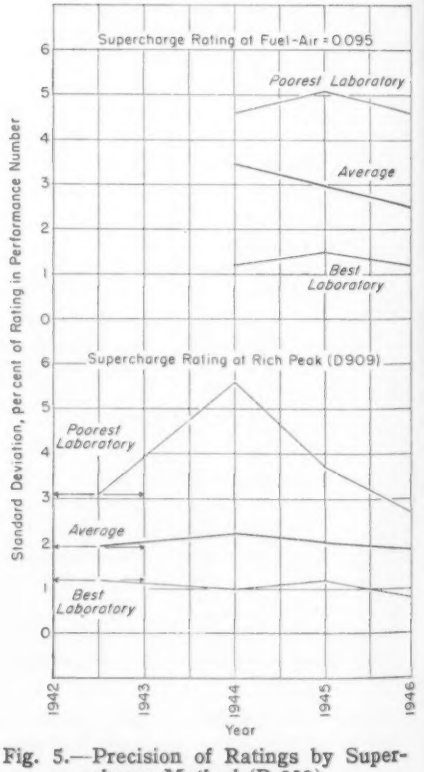


Fig. 5.—Precision of Ratings by Supercharge Method (D 909)

The average, poorest, and best values of the standard deviation of rating by Exchange Group members are shown for each year.

TABLE VIII.—CALCULATED AND ACTUAL DEVIATIONS OF RATINGS BY AVIATION METHOD IN 1946.

Deviations in Performance Number Not Larger Than	Calculated from Standard Deviation	Actual
1	146	191
2	261	307
3	340	359
4	385	388
5	406	404
6	414	408
7	417	413
8	418	416
9	418	418

distribution. For this reason, Fig. 6 differs from the analogous Fig. 3, for motor fuels in that only the line of 90 per cent probability is shown. Figure 6 shows the number of ratings which must be made on a fuel to yield an average having a desired precision. The number of ratings indicated by the line gives a 90 per cent probability that their average is within the desired amount of the true value. As the precision of Aviation ratings is a constant percentage of the performance number rating of the fuel, the precision scale is marked in per cent of rating.

As an example of the use of Fig. 6, suppose you have obtained a supply of aviation gasoline for use under conditions which require a fuel of at least 70 performance number. You have obtained an Aviation rating of 71.5 performance number on the fuel. Is it safe for use? Figure 6 shows that once in ten times a single rating may be in error by 3 per cent, or 2.1 performance number in this case. It would therefore not be safe to assume that this fuel was satisfactory, on the basis of one test. However, if one or two additional *independent* ratings yield an average not lower than 71.5 performance number, there is a 9 to 1 chance that the fuel will meet the requirements.

As the precision of rating aviation fuels by the Motor method is approximately equal to that of rating by the Aviation method, Fig. 6 can be used for aviation fuel ratings by either method.

Ratings by the Supercharge method both at a fuel-air ratio of 0.095 and at the rich peak, are nearly normal in distribution. In both cases there is an unduly large proportion of very small and very large errors, at the expense of the middle-sized errors. However, the difference between the calculated and the observed number of values is not as great as was the case for the Aviation ratings.

Figures 7 and 8 give similar information for the Supercharge ratings to that given by Fig. 6 for the Aviation ratings. During the war, Government acceptance of aviation gasoline was

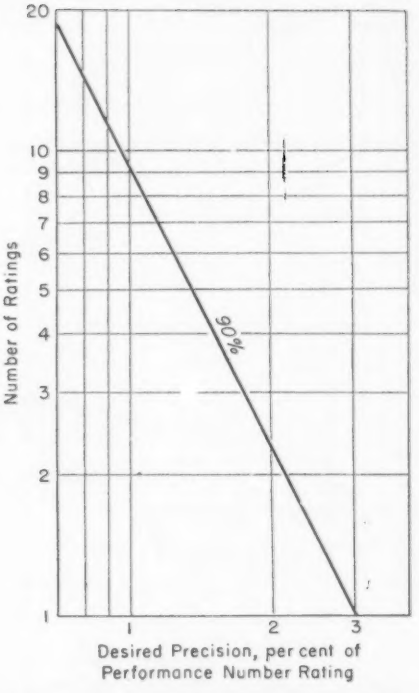


Fig. 6.—Number of Ratings Required to Yield an Average Having a Desired Precision by Aviation Method (D 614).

The number of ratings indicated by the line gives a 90 per cent probability that their average will be within the desired amount of the true value. Note that precision, which varies with rating level, is expressed in per cent of rating.

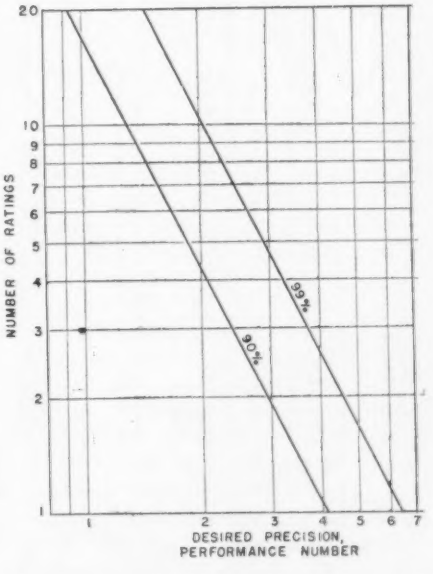


Fig. 7.—Number of Ratings Required to Yield an Average Having a Desired Precision by Supercharge Method at a Fuel-Air Ratio of 0.095.

The number of ratings indicated by the lower line gives a 90 per cent probability that their average will be within the desired amount of the true value. The upper line similarly gives a 99 per cent probability.

usually based on one test. Figure 8 shows that, had it not been for the pains taking control exercised by the petroleum industry, batches as much as 5 performance number below the desired value might have been obtained unknowingly by this procedure.

Another use of figures such as Figs. 7 and 8 is in determining when to reject one or more ratings of a group. The "99 per cent" line of Fig. 8, shows that a rating which departs from the group average by 5 performance number is suspect. It has less than one chance in a hundred of arising from the normal sources of error. Its existence is probably the result of some abnormal circumstance, such as the wrong sample,

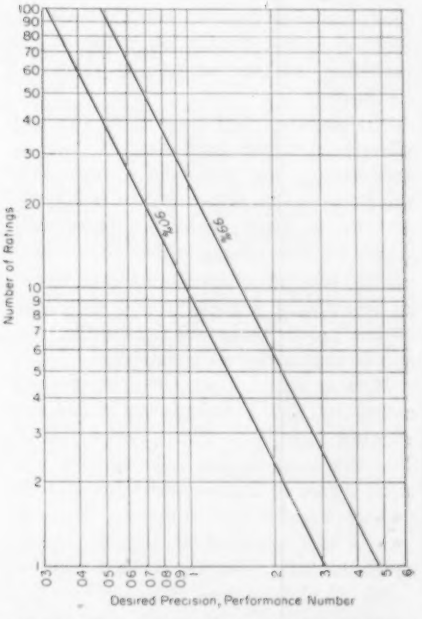


Fig. 8.—Number of Ratings Required to Yield an Average Having a Desired Precision by Supercharge Rich Method (D 909).

The number of ratings indicated by the lower line gives a 90 per cent probability that their average will be within the desired amount of the true value. The upper line similarly gives a 99 per cent probability.

contamination of the sample, or a large error in recording test data. Similarly, from the "99 per cent" line, if the average of, say, three ratings departs from the average of a larger group by three performance number, the reliability of the three ratings is in doubt.

Factors Affecting Precision:

Relatively little has been developed by this or the earlier analyses (10, 12) on the factors affecting the precision of rating aviation fuels. For one thing, earlier experience on the Research and Motor methods had led already to the control of certain factors, such as humidity, temperatures, and overhaul pe-

riods. For another, the characteristics of aviation fuels, especially of the higher grades, are less diverse than those of motor fuels. There is thus less opportunity for comparing the behaviors of different types of fuels.

As stated earlier, the standard deviation of rating aviation fuel by the Motor and Aviation methods increases directly with the performance number of the fuel. Even apart from this fact, fuels which are not rated precisely by the Aviation method generally are not rated precisely by the Motor method either. Similarly, fuels not rated well at a fuel-air ratio of 0.095 by the Supercharge (CFR F-4) method are quite unlikely to be rated well at the rich peak. On the other hand, the precision of rating a fuel by the Aviation method is practically no guide to the precision of its rating by the F-4 method.

An aviation fuel analog of the sensitivity of motor fuels may be had by subtracting the Aviation rating from the supercharge rating at the rich peak. As the aviation rating is practically equal to the former supercharge lean rating, the difference as obtained above is practically a measure of the slope of the supercharge rating curve, relative to that of the reference fuels.

It was found that the precision of rating by the Aviation method is not affected by this fuel "sensitivity." The precision at the supercharge rich peak seems to deteriorate slightly with greater sensitivity; however, this effect is not established beyond doubt by these data. At the fuel-air ratio of 0.095 the precision deteriorates unmistakably with the more "sensitive" fuels.

Correlation of Motor and Aviation Ratings:

At the request of the Air Technical Service Command, Army Air Forces, a study was made of the possibility of using Motor engine ratings to estimate the Aviation ratings of aviation fuels, and of using Aviation engine ratings to estimate the Motor rating of all-purpose motor fuel. The objective sought was to eliminate the need for both types of engines (or a change-over) at overseas bases. As the information developed by this study (13) may be of interest to laboratories having only one of these engines, it is summarized herein.

All available data on samples tested by both methods were analyzed. It was found that both fuels and fuel components were rated practically the same by the two methods, if unleaded.

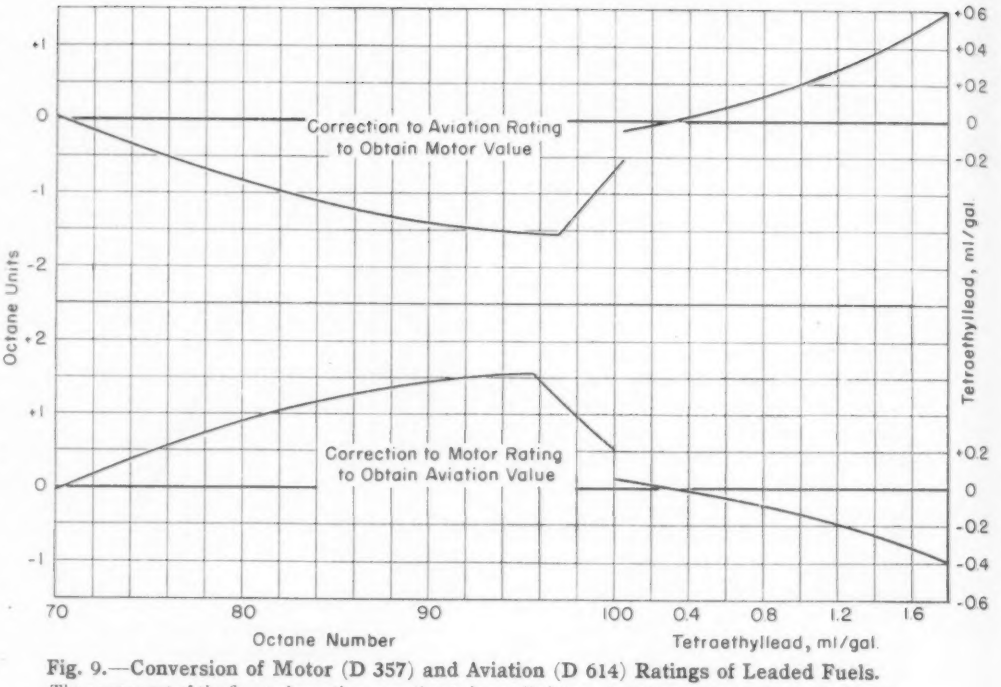


Fig. 9.—Conversion of Motor (D 357) and Aviation (D 614) Ratings of Leaded Fuels.
The upper part of the figure shows the correction to be applied to an Aviation rating to obtain the Motor rating.
The lower portion shows the correction to a Motor rating to obtain the Aviation value. Clear fuels usually have about equal ratings by these test methods.

TABLE IX.–AVERAGED DATA ON DIESEL EXCHANGE SAMPLES, 1942 TO 1946.

Sample	Cetane Number	Standard Deviation	Greatest Deviation	Hand-wheel Setting	Sample	Cetane Number	Standard Deviation	Greatest Deviation	Hand-wheel Setting
D-125..	50.5	0.97	4.9	1.497	D-163..	53.3	1.49	2.8	1.525
D-126..	47.2	0.97	2.0	1.461	D-164..	43.5	1.24	2.0	1.401
D-127..	46.5	1.12	2.2	1.456	D-165..	57.8	1.58	2.8	1.560
D-128..	62.9	1.35	2.8	1.589	D-166..	44.0	1.53	3.1	1.408
D-129..	30.8	1.48	2.7	1.167	D-167..	59.8	1.89	4.5	1.577
D-130..	29.8	0.69	1.3	1.139	D-168..	53.0	1.32	3.1	1.503
D-131..	37.9	1.13	1.8	1.327	D-169..	40.6	1.25	2.9	1.374
D-132..	55.8	1.94	3.8	1.524	D-170..	42.4	2.04	4.3	1.424
D-133..	53.5	1.39	2.9	1.502	D-171..	52.1	1.57	11.1	1.514
D-134..	51.3	0.98	1.8	1.483	D-172..	50.4	1.21	2.4	1.534
D-135..	29.2	1.06	2.2	1.155	D-173..	53.3	0.87	2.3	1.530
D-136..	49.4	0.86	1.5	1.476	D-174..	59.0	1.84	4.0	1.581
D-137..	61.2	2.06	3.9	1.590	D-175..	52.2	1.38	2.8	1.521
D-138..	47.3	1.24	2.9	1.484	D-176..	53.3	1.51	3.1	1.521
D-139..	49.1	1.13	2.1	1.499	D-177..	46.2	1.38	2.7	1.460
D-140..	46.7	1.09	1.9	1.467	D-178..	54.0	1.61	3.1	1.521
D-141..	44.5	1.48	3.4	1.450	D-179..	50.3	1.80	3.5	1.502
D-142..	48.5	1.07	2.2	1.487	D-180..	50.5	1.47	3.8	1.498
D-143..	44.5	0.93	2.2	1.430	D-181..	52.6	1.65	4.3	1.552
D-144..	54.7	1.08	2.3	1.520	D-182..	45.0	1.38	2.4	1.472
D-145..	48.1	1.05	2.2	1.477	D-183..	47.3	1.59	3.6	1.491
D-146..	51.5	1.28	3.5	1.513	D-184..	52.9	1.40	3.6	1.516
D-147..	49.7	1.83	3.6	1.494	D-185..	50.7	2.74	5.1	1.497
D-148..	50.8	1.44	3.0	1.499	D-186..	52.3	0.97	2.0	1.535
D-149..	42.4	1.08	2.4	1.395	D-187..	39.7	0.97	2.1	1.414
D-150..	51.0	0.92	1.9	1.513	D-188..	40.3	1.25	2.7	1.421
D-151..	51.2	1.78	3.9	1.499	D-189..	49.5	1.90	4.5	1.526
D-152..	50.7	1.43	3.0	1.518	D-190..	44.4	1.82	3.7	1.465
D-153..	47.7	1.82	3.6	1.518	D-191..	54.4	1.52	3.1	1.544
D-154..	42.3	0.99	2.0	1.469	D-192..	49.1	1.11	2.7	1.460
D-155..	44.6	1.37	3.2	1.484	D-193..	51.9	1.64	4.3	1.492
D-156..	51.9	1.17	2.4	1.581	D-194..	49.9	1.44	3.1	1.494
D-157..	50.6	0.82	1.7	1.527	D-195..	40.3	1.41	4.2	1.544
D-158..	42.2	1.03	2.5	1.417	D-196..	54.2	1.37	3.3	1.518
D-159..	49.8	1.42	3.5	1.494	D-197..	46.5	1.61	1.9	1.456
D-160..	49.7	1.20	2.6	1.493	D-198..	50.7	1.00	1.9	1.509
D-161..	60.2	1.68	4.1	1.600	D-199..	55.9	0.96	1.8	1.553
D-162..	38.5	1.36	2.5	1.357					

The ratings of leaded fuels, however, differed by the two methods, but in a consistent manner. Figure 9 is a chart for the conversion of Aviation to Motor ratings, and Motor to Aviation ratings. Applying Fig. 9 to the ratings of 85 Exchange Group fuels, in three cases the chart is in error by slightly over 1 octane number, for the fuels rating from 70 to 100 octane number, and in two cases it is in error by a similar amount for fuels rating above 100 octane number.

It should be understood that this chart is not applicable to pure hydrocarbons, or to unusual fuels, particularly those which have high aromatic content. With these reservations, the chart may be used to translate Motor and Aviation ratings with considerable assurance. Actually, on the basis of the Exchange Group data, a rating made by

TABLE X.—INSPECTION DATA ON 1946 DIESEL EXCHANGE SAMPLES.

Sample	Gravity	Saybolt Universal Viscosity at 100 F., sec.	Sulfur, per cent	Aniline Point, deg. Cent.	Distillation, deg. Fahr.					Distillation Recovery, per cent	Distillation Loss, per cent
					First Drop	10%	50%	90%	End Point		
D-186	37.2	34.9	0.17	151.4	318	432	500	593	634	...	...
D-187	33.5	35.2	...	139.5	393	440	486	584	658	99.0	0.0
D-188	39.2	1.707[a]	...	137	365	394	434	490	515	98.0	1.0
D-189	34.9	36.4	...	151	344	454	532	585	613	97.5	1.5
D-190	34.0	35.0	0.375	137.1	369	436	498	573	634	...	...
D-191	38.6	35	...	68.8	384	443	504	574	614	...	...
D-192	36.0	35.4	...	153	378	437	506	598	702	98.0	1.0
D-193	42.4	30.4	...	149.0	350	396	433	478	520	98.5	0.0
D-194	34.9	37.0	0.605	...	356	426	534	622	676	98.0	1.0
D-195	31.8	35.4	0.223	...	419	455	496	581	637	99.0	0.0
D-196	37.5	36.6	0.161	...	431	473	511	578	641	99.0	0.0
D-197	37.1	32.8	...	135.5	360	424	464	542	610	99.0	0.2
D-198	36.8	35.5	...	148.5	356	430	510	604	645	97.8	0.6
D-199	37.5	37.0	0.15	164.3	433	480	529	583	626	...	...

[a] Viscosity in centipoises

either method and converted by means of the chart will be only 10 per cent less precise than a direct determination, on the average.

Diesel Fuels

Ratings of Exchange Samples:

During the period covered by this analysis, Diesel fuel samples D-125 to D-199 have been tested by the CFR Diesel Exchange Group. The rating data on these samples are given in Table IX. The cetane numbers of the fuels tested ranged from 29.2 to 62.9, and the standard deviations of rating varied from 0.69 to 2.74 cetane number. Inspection data on fuels D-186 to D-199 are given in Table X.

The test data on earlier samples have not been published in full. An analysis (4) of ratings was made on samples D-1 to D-37, and was presented to the CFR Committee in September, 1939. The average ratings and standard deviations of samples D-1 to D-124 have been compiled and are given in a CFR report (14).

Ratings made at a fuel flow rate of 10 ml. per min. have been included in obtaining the average values for samples D-41 to D-91. An analysis (14) of 279 pairs of ratings made at 13 and at 10 (or occasionally 11) ml. per min. showed that ratings at these fuel rates did not differ, except as affected by experimental error. The average rating at 13 ml. per min., for the 279 ratings, was 47.37 cetane number, as compared with 47.38 for the corresponding ratings at the lower fuel rates.

Precision of Rating:

A plot of the average precision of rating the exchange samples for each year is given in Fig. 10. An apparent trend toward higher precision before the war was reversed, and 1945 was the worst year thus far. Considerable improvement was shown in 1946. The upper and lower lines on Fig. 10 show the highest and the lowest precision attained by the laboratories for each year.

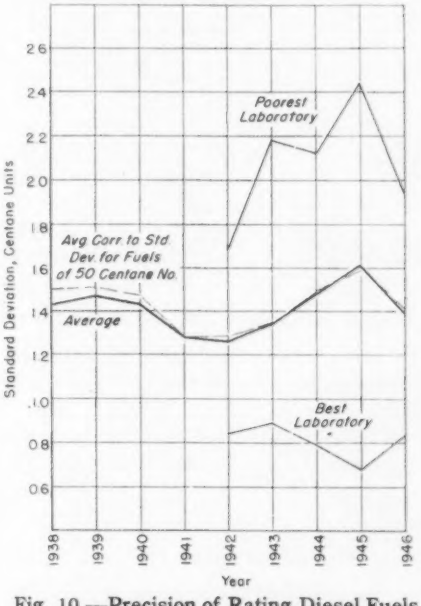


Fig. 10.—Precision of Rating Diesel Fuels by the Cetane Method (D 613).

The average, lowest, and highest values of the standard deviation of rating by Exchange Group members is shown for each year. As precision of rating varies with cetane number of the fuel, the broken line shows the average corrected to fuels of 50 cetane number.

It is apparent that there is much difference in precision between the different laboratories of the group. In the period 1941 to 1945, one fourth of the laboratories in the group accounted for half of all of the annual precision values below 1.4 cetane number. Half of the group had seven eighths of all such values. Two of the group members have 5-yr. averages of 1.0 cetane number. On the average, the poorest precision value has been more than $2\frac{1}{2}$ times that of the best. It seems probable, therefore, that the average precision of rating Diesel fuels could be improved at least 30 per cent without change in the method, merely by improving technique and attention to details.

A tendency for the standard deviation to increase at higher cetane numbers has been reported in earlier analyses (4, 14, 15) and is confirmed by such that the error at 20 cetane number is 76 per cent of that at 50 cetane number, and the error at 80 is 124 per cent of that at 50 cetane number.

How to Use the Precision Measures:

Earlier analyses (14, 15) have shown the errors of cetane ratings to be normally distributed. Except for an undue occurrence of large errors, the 1942 to 1946 data (Table IX) are normal, as are the standard deviations. Inferences drawn from the precision measures may therefore be considered reliable.

Figure 11 shows the number of ratings required to yield an average which will be within a desired amount of the true cetane number of a fuel. The lower curve is used where a 90 per cent probability is sufficient, while the upper curve gives the 99 per cent probability values. This figure was computed for

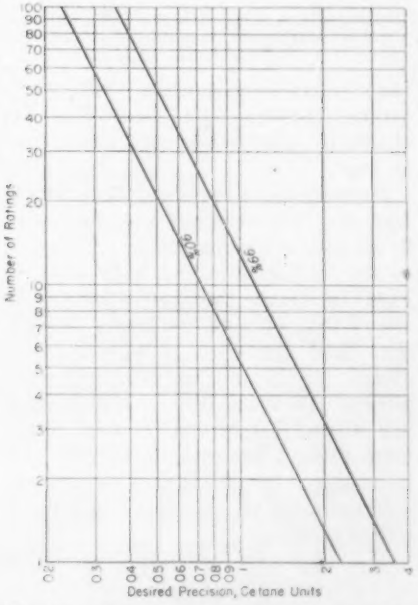


Fig. 11.—Number of Ratings Required to Yield an Average Having a Desired Precision by the Cetane Method (D 613).

The number of ratings indicated by the lower line gives a 90 per cent probability that their average will be within the desired amount of the true value. The upper line similarly gives a 99 per cent probability.

TABLE XI.—CORRELATIONS.

Fuel	Quantity	Quantity	r	$1 - P_r$
Motor	Research standard deviation (1942–44)	Research rating	−0.07	0.62
	Research standard deviation (1945)	Research rating	−0.30	0.31
	Research standard deviation (1946)	Research rating	−0.04	0.90
	Research standard deviation (1942–46)	Research rating	−0.05	0.68
	Research standard deviation (1942–44)	Sensitivity	−0.10	0.50
	Research standard deviation (1945)	Sensitivity	−0.08	0.79
	Research standard deviation (1946)	Sensitivity	+0.11	0.72
	Research standard deviation (1842–46)	Sensitivity	0.00	1.00
	Motor standard deviation (1942–44)	Motor rating	+0.04	0.80
	Motor standard deviation (1945)	Motor rating	−0.55	0.06
	Motor standard deviation (1946)	Motor rating	−0.26	0.39
	Motor standard deviation (1942–46)	Motor rating	−0.06	0.57
	Motor standard deviation (1942–44)	Sensitivity	+0.24	0.09
	Motor standard deviation (1945)	Sensitivity	+0.01	0.98
	Motor standard deviation (1946)	Sensitivity	+0.35	0.90
	Motor standard deviation (1942–46)	Sensitivity	+0.19	0.09
Aviation	Motor standard deviation	Motor rating	+0.62	10^{-7}
	Aviation standard deviation	Aviation rating	+0.53	10^{-5}
	Motor standard deviation	Aviation standard deviation	+0.57	10^{-6}
	Supercharge at 0.095 standard deviation	Supercharge rich standard deviation	+0.63	10^{-7}
	Aviation standard deviation	Supercharge rich minus aviation rating	−0.02	0.89
	Supercharge rich standard deviation	Supercharge rich minus aviation rating	+0.27	0.04
	Supercharge at 0.095 standard deviation	Supercharge rich minus aviation rating	+0.57	10^{-6}
	Aviation rating	Supercharge rich minus aviation rating	+0.04	0.81
	Aviation rating	Supercharge lean, rating	+0.98	10^{-6}
	Aviation rating of A-130	Supercharge at 0.095, rating of A-130	+0.19	0.51
	Aviation rating of A-130	Supercharge rich, rating of A-130	+0.28	0.17
	Aviation Standard deviation	Motor Standard deviation	+0.40	10^{-4}
	Rating	Rating		
	Supercharge rich standard deviation	Supercharge rich, rating	+0.01	0.95
	Supercharge at 0.095 standard deviation	Supercharge at 0.095, rating	−0.08	0.53
	Aviation standard deviation	Supercharge rich, standard deviation	+0.22	0.09
Diesel	Standard deviation	Humidity	+0.08	0.70
	Cetane ratings, D-172 to D-199	Humidity	−0.52 to +0.80	<0.01 to 0.90
	Departure of handwheel setting from avg. value	Humidity	−0.42	0.04
	Departure of handwheel setting from avg. value	Cetane rating, D-172 to D-199	−0.47 to +0.57	0.02 to 0.92

TABLE XII.—STATISTICAL PROPERTIES OF DATA.[a]

Fuel	Quantity	Average	Standard Deviation	Chi Square Probability	Skewness		Kurtosis	
					g_1	P_{g1}	g_2	P_{g2}
Motor (octane number)	Research ratings	..	0.448	0.02	+0.59	<0.01	+1.16	<0.01
	Research standard deviations	0.47	0.18	0.05	+1.21	<0.01	+0.57	0.28
	Motor ratings	..	0.417	0.21	+0.16	0.26	+0.20	0.50
	Motor standard deviations	0.47	0.15	0.32	+0.74	<0.01	+0.96	0.07
Aviation (performance number)	Motor ratings	..	2.50	0.05	−0.63	<0.01	+1.93	<0.01
	Motor standard deviations	2.10	1.13	0.04	+1.63	<0.01	+3.67	<0.01
	Aviation ratings	..	2.31	<0.01	−0.51	<0.01	+1.95	<0.01
	Aviation standard deviations	1.85	0.57	0.14	+0.58	0.03	−0.18	0.72
	Supercharge at 0.095 ratings	..	2.50	0.55	−0.07	0.62	+1.26	<0.01
	Supercharge standard deviations	3.1	1.07	0.03	+0.94	<0.01	+0.37	0.36
	Supercharge rich ratings	..	1.87	0.01	−0.03	0.99	+2.51	<0.01
	Supercharge rich standard deviations	2.0	0.69	0.29	+1.40	<0.01	+3.65	<0.01
Aviation (percentage of rating)	Motor standard deviations	2.07	0.92	0.20	+1.39	<0.01	+3.10	<0.01
	Aviation standard deviations	1.87	0.53	0.70	+0.28	.28	−0.26	0.61
Diesel (cetane number)	Cetane ratings	..	1.39	0.10	+0.00	0.99	+1.26	<0.01
	Cetane standard deviations	1.36	0.32	0.30	+0.19	0.75	−1.17	0.31

[a] The ratings covered are those obtained in 1946. Properties of the standard deviations are for 1942 to 46. The notation follows Snedecor (16).

the standard deviation for 1946 of 1.39 cetane number, and from Fig. 10, should be true for the next year or two at least.

Suppose you have a supply of Diesel fuel, and have obtained a cetane rating of 52 cetane number on it. Is it safe to use in engines which *must* have at least 50 cetane number? Figure 11 shows that once in ten times (90 per cent line) the error of a rating will exceed 2.3 cetane number, and that once in 100 times (99 per cent line) it will exceed 3.6 cetane number. Two more ratings, however, if they do not lower the average, will give you reasonable assurance that the fuel is at least 50 cetane number.

The discussion given in connection with the analogous Fig. 3, in the section on Motor Fuels, applies to Fig. 11 as well. Tests *must* be independent if the figure is to apply. Other pertinent information, such as earlier ratings on the same stock, or ratings on components, with knowledge of their blending relations, has the effect of additional ratings on the fuel. In short, the figure applies for independent ratings on an unfamiliar fuel. The precision scale may be adjusted if desired. Laboratories having a precision of 1.0 cetane number should reduce the values by 30 per cent. As precision varies with the cetane number level, the scale could also be adjusted to compensate for this change.

Factors Influencing Precision:

The ratings of Diesel samples in general are not affected by the prevailing air humidity. The ratings of two fuels, D-178 and D-198, appear to have been affected by humidity. If this effect was not the result of chance, the ratings of these fuels vary by 4.2 and 2.5 cetane number, respectively, for a humidity change of 100 grains per pound of dry air. A further study of the effect of humidity on ratings would be desirable.

The precision of rating is not affected by humidity. It also is not affected by the extent to which the handwheel setting (index of compression ratio) departs from the average value. The handwheel setting, for a fuel of a given cetane number, however, does appear to change with humidity. From the data obtained in 1945 and 1946, this change would amount to 0.05 in. in handwheel setting for a humidity change of 100 grains per pound of dry air. Different laboratories in the group tend to run high or low of the average handwheel setting by as much as 0.1 in. Such a tendency, however, was not accompanied by any tendency to rate fuels higher or lower than the average.

During most of the period covered by this report, the Caterpillar Tractor Co. participated in the exchange tests, using a Caterpillar engine equipped with a "cetane valve." Their results averaged 0.4 cetane unit above the group average, a departure equalled by one third of the laboratories using the standard Cetane engine. Their pre-

cision of rating was slightly below the group average, but it was better than that of one third of the other laboratories. It is concluded that the Caterpillar "cetane valve" is an alternate means of determining cetane number, but one which does not promise higher precision.

Calibrations of Reference Fuels:

Several Exchange Group laboratories have expressed the opinion that the calibrations of some batches of reference fuels have been inaccurate. These calibrations, unlike those of motor and aviation primary and secondary reference fuels, are not made or certified by the National Bureau of Standards.

The calibration of a secondary reference fuel is essentially a conversion, in the form of a table, chart, or formula, which has been agreed upon as the result of tests. If the tests have been planned carefully, and the data used properly, the calibration will have no *appreciable* error. If there is appreciable error, ratings based on the erroneous calibration will not agree with ratings based on the primary, or on properly calibrated secondary reference fuels. A study of the deviations obtained with each of several reference fuel combinations should thus reveal calibration error.

Such studies were made on all reference fuel systems for which enough data were available. No evidence of error was found for the systems: 1801–9/1802–2, 1801–9/α-methylnaphthalene, and n-cetane/α-methylnaphthalene. By far the most data were obtained on 1801–10/1802–3, and no slightest evidence of error was shown for this system. The system 1801–8/1802–1; however, is undoubtedly in error, giving ratings averaging three fourths of a cetane number low in the range near 50 cetane number. There are indications that this reference fuel system was correct at 30 cetane number and in error by one unit at 60 cetane number.

Nonmember Participation Tests:

In the five year period covered by this analysis, 213 ratings of 21 samples of Diesel fuels have been reported by nonmembers participating in the semi-annual tests. It would indeed be difficult to prove from the data of these tests that monthly participation improves the precision of rating. The nonmember participants have had higher precision on 13 of the 21 samples, and equal precision on two of the remainder. For the 21 samples, the standard deviation of the nonmembers has averaged 97 per cent of that of the members. The member average on these semi-annual samples was within a few per cent of their value for all samples rated in this period.

Acknowledgement:

We wish to express acknowledgment to Miss Katherine I. Biggs and to Miss Anne Kessinger for their valuable assistance in tabulating and computing the test data.

REFERENCES

(1) Donald B. Brooks, "The Precision of Knock Rating," *SAE Journal*, Vol. 39, October, 1936, pp. 22–24.
(2) Donald B. Brooks and Robetta B. Cleaton, "The Precision of Knock Rating, 1936–1938," *Transactions*, Soc. Automotive Engrs., Vol. 45, October, 1939, pp. 449–456.
(3) Donald B. Brooks and Robetta B. Cleaton, "The Precision of Motor Fuel Testing," *Transactions*, Soc. Automotive Engrs., Vol. 50, September, 1942, pp. 392–401.
(4) C. E. Arbuthnot, "Reproducibility of Cetane Number Determinations," CFR Report, September 11, 1939.
(5) A.S.T.M. Manual of Engine Test Methods for Rating Fuels, March, 1948. (Issued as separate publication.)
(6) T. A. Boyd, "The Bouncing-Pin Has Its Silver Anniversary," *SAE Journal*, Vol. 54, November, 1946, pp. 55–59.
(7) Donald B. Brooks, "A Review of the Development of Reference Fuel Scales for Knock Rating," *Transactions*, Soc. Automotive Engrs., Vol. 54, August, 1946, pp. 394–403.
(8) Donald B. Brooks, "The Precision of Rating Motor Fuels, 1942–1944," CFR Report, CRC-146, February 6, 1945.
(9) Donald B. Brooks, "The Precision of Rating Motor Fuels, 1945," CFR Report, CRC-147, May 15, 1946.
(10) Donald B. Brooks, "The Precision of Rating Aviation Fuels," CFR Report, CRC-24, January 7, 1945.
(11) Donald B. Brooks, "Report on Tests of Aviation Precision Samples," CFR Report, CRC-26, June 2, 1945.
(12) Donald B. Brooks, "The Precision of Rating Aviation Fuels, 1945," CFR Report, CRC-31, May 24, 1946.
(13) Donald B. Brooks, "Correlation of F-2 and F-3 Ratings of Fuels and Components," CFR Report, CRC-28, February 8, 1946.
(14) Donald B. Brooks, "The Precision of Rating Diesel Fuels, 1942–1944," CRF Report, CRC-118, March 17, 1945.
(15) R. B. Cleaton, "The Precision of Rating Diesel Fuels, 1945," CFR Report, CRC-121, July 18, 1946.
(16) George W. Snedecor, "Statistical Methods," The Iowa State College Press, Ames, Iowa (1946).

The Concept of Organic Coating Hardness[1]

By M. H. Switzer[2]

THE purpose of this paper is to portray the development of concepts which have resulted from the activities of the Group on Hardness of Organic Coating Films of Subcommittee XVIII on Physical Properties of Materials of A.S.T.M. Committee D-1 on Paint, Varnish, Lacquer, and Related Products. It should be emphasized that the thoughts that will be presented are due mainly to the efforts of the Hardness Group members; the author is merely acting as their spokesman. A wide diversity exists among paint technologists concerning the concepts connoted by the term "coating hardness" and many instruments employing several different principles of operation are in use for reducing the concepts to numerical measurements. Although the Hardness Group constitute a good cross-section of opinion on the subject from the paint technologist's point of view, the thoughts of the Group members seem to have reached the stage where more general consideration by the A.S.T.M. members appears to be advisable. Accordingly, these thoughts are presented here for comment and criticism.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Presented at the meeting of Committee D-1 on Paint, Varnish, Lacquer, and Related Products, held at the Fifty-first Annual Meeting of the Society, Detroit, Mich., June 23, 1948.

[2] Chairman, Hardness Group, Subcommittee XVIII, Committee D-1; Technical Associate, C. Olin Ball, Consulting Food Technologist and Associates, Toledo, Ohio.

THE SURVEY

The initial activity of the Hardness Group was to make a survey of 25 manufacturing concerns whose products were such that it seemed logical for coating hardness to be a matter of consideration to them. The questionnaire sent out for this survey contained the following questions:

1. Does your organization employ measurements of film hardness as

part of the evaluation of the characteristics of organic coating films?

2. If so, what character of hardness measurement is employed? Select from among the following classifications:
   A. Scratch Hardness
   B. Pendulum or Entropy Hardness
   C. Indentation Hardness
   D. Others
3. If the method employed is one or more of A, B, or C in Question 2, describe briefly the salient details, referring to that method in Gardner's Handbook which approximates your method most closely.
4. If the method employed is answered by D of Question 2, a full description will be appreciated.
5. Do you consider it of advantage to have a standard method of conducting hardness tests as one of the A.S.T.M. procedures.
6. If the answer to Question 5 is Yes, do you feel that there should be more than one standard method specified?
7. Would your organization be willing to cooperate in one of the following capacities in the technical work which will be involved in drawing up the required standard procedures? (There then followed a statement of the responsibilities associated with several classifications of group membership.)

The results of this questionnaire may be summarized briefly as follows:

1. Hardness tests are quite generally employed.
2. It is probable that about an equal number of laboratories employ scratch hardness tests as employ pendulum hardness tests; indentation hardness measurements are less used.
3. There are a large number of different methods employed to determine scratch hardness, and many laboratories employ more than one method; the use of the Sward Rocker predominates in the determination of pendulum hardness. Some special methods are employed for specific purposes.
4. The need for standard methods of conducting hardness tests was expressed; more than one standard method will be required.
5. The response to the questionnaire was gratifying. Twenty-five questionnaires were sent out; nineteen were returned, of which two indicated the respective laboratories did not conduct film hardness tests. In the organization of standard tests, nine laboratories were willing to undertake cooperative work, three would like to be in the group but could not undertake cooperative work, three were willing to offer constructive criticism, and two wanted only to be kept advised of results.

In general, the returned questionnaires indicated that a large variety of different methods were being employed in industry to assess a property of organic coating films rather loosely designated as hardness. Ten different methods of determining what was designated as scratch hardness were reported. These methods are as follows:

Fingernail,
Hoffman Hardness Tester,
Bell Laboratories Hardness Tester,
du Pont Hardness Tester,
Hand knife,
Hand pencil,
The Microknife,
The Taber Shear Attachment,
Wilkinson Pencil Hardness Tester, and
Modified Bell Laboratories Hardness Tester.

Only two methods were reported for determining pendulum or entropy hardness. These were the Sward Hardness Rocker and the Walker-Steele Swinging Beam.

Thus, some modification of scratch hardness was found to be employed twenty-one times, entropy hardness fourteen times and indentation hardness five times. A wide variety of methods was employed for scratch hardness while entropy hardness tests were performed almost entirely by the Sward Rocker method.

The laboratories employing indentation hardness tests indicated preference for only two test methods as follows: Pfund and Print Resistant.

Two of the replies to the questionnaire cited other principles of hardness measurement which may be summarized as follows:

Information concerning hardness as a function of gouging resistance on very thick films is required where the properties of the substrate as well as the coating are expected to be a part of the test measurement. The usual tests employed for thin films on metal or glass do not serve the purpose. The test employed now is similar to indentation hardness determinations except that it involves not only deformation which occurs under compression but also the recuperation which follows removal of the compressive load.

The second of these two replies mentioned various testing methods designed in accordance with customer requirements. Such properties as distensibility and elongation are now measured and are considered functions of coating film hardness; mandrel bending tests and ball and hammer impressions to various pepths on painted steel panels are now employed.

At about the time that this survey was made, an article appeared in the *Official Digest*, December, 1946, page 653, written by P. C. Wheeler of the Dallas Paint and Varnish Production Club. This article, reporting the results of a survey conducted on a larger scale than ours, supports the findings which have been reported here.

Meetings

Following this survey, the first meeting of the Hardness Group was called in June, 1947, in Atlantic City. The expressed purpose of this meeting was to provide an opportunity for expressions of opinions by those present concerning their understandings of what concepts were connoted by the term hardness as applied to organic coating films. It was hoped that such expressions would serve to broaden the understanding of the group membership concerning the nature of the problem at hand, and it is believed that this purpose was in large measure achieved.

The consensus of opinion was that the subject of hardness is very complex. It seems that several of the physical characteristics of an organic coating film are simultaneously judged and mentally weighed in order of relative importance to obtain the usual expression of hardness judgment. The same physical characteristics of films are not always employed, and the weighing of the importance of the various physical characteristics chosen is not always carried out in the same manner; these choices depend upon personal judgment of the operator and are based upon his experience in the correlation of the hardness test with results in practical use of the material to which the test applies.

At the time of this first meeting, the purpose of the group was established to concern itself with (1) a study of the subject of hardness to attempt to define some of the physical properties or attributes of an organic coating film which form a part of the consideration of hardness, (2) a limitation of this study toward the development of procedures for measuring the attributes of hardness from the standpoint only of films which are matured to the state where they are ready for the intended

use, and (3) a further limitation to smooth films of organic coatings as they are normally applied on a substrate. It was decided that two pairs from the group membership would draw up reports for circulation to the group in which reports they would attempt to separate and define the various attributes of hardness which must be given consideration.

Part of the report prepared jointly by Mr. H. E. Malone of the Western Electric Co. and Mr. R. J. Phair of Bell Telephone Labs. is quoted as follows:

"In none of the methods now used for measuring hardness is the result given the dimensions of an absolute physical quantity, and it would be difficult to do so because of the indefinite influence of a number of properties of the substance tested on the result obtained.

"A material is said to be hard if it resists penetration or is not easily scratched. When one body deforms or penetrates another, the forces which maintain the positional arrangement of the constituent particles have been overcome and compression or elongation occurs. The deformation may be elastic, plastic, or brittle. In an elastic deformation, the part so deformed will recover its original size and shape when the stressing force is removed. A plastic deformation assumes that the elastic limit has been exceeded and that the deformation will remain after the external pressure has been relaxed. Brittleness is manifested by a complete rupture of the attractive forces with little or no deformation of the stressed member. We may further consider that an abrasive deformation occurs when some of the material has been removed from the parent body and we may thus differentiate between abrasive deformation and plastic strain wherein the component particles have been displaced but not completely removed from their sphere of attraction.

"One further characteristic to be considered is creep, or plastic yielding. If a weighted penetrator is applied to the surface of an organic coating material there will be an initial immediate deformation and, as time elapses, there will be a further penetration without increase in load. The time element should therefore appear in the method selected to permit establishment of a condition of equilibrium.

"As it is difficult to determine to what extent elastic recovery may occur in a deformed organic film, it seems desirable to measure the amount of deformation before the deforming force is removed.

"Our conception of hardness of organic films may be expressed as resistance to compressive deformation with time. The apparatus which we currently employ is the Pfund Hardness Tester in which a standardized load is applied to a hemispherical quartz penetrator for a definite time interval and the amount of penetration is then measured by determining the diameter of the line of intersection of the hemisphere with the plane surface of the film. Perhaps a further modification consisting of the superimposing of a second load and an expression of hardness as the additional deformation occurring as in the Rockwell type testers for metals may be considered.

"It is felt that the above method gives a reasonable picture of the through hardness of the coating but, because of the skin effect occurring in organic films, it should be supplemented by another measurement which we refer to as mar resistance.

"Determinations of mar resistance or the ability to resist surface scarring and scratching such as may occur in fabrication or use of coated parts is accomplished by moving a coated test specimen beneath a needle point which is increasingly loaded until the surface of the film is ruptured.

"Although attempts to relate abrasion resistance to hardness have been made, experimental evidence indicates little correlation between this characteristic and the resistance to deformation for organic coatings. For instance, the abrasion resistance of materials such as the resin-buna N blends when measured on the carborundum air blast abrasion tester is much higher than that obtained for a hard baked phenolic varnish, but it is obvious that the former is much the softer of the two materials.

"From the standpoint of translation of the measured quantity to indication of behavior in actual usage, the penetration technique has been found reasonably satisfactory in determining the extent to which organic insulating coatings applied to a coil core will resist the deforming action of the wire as it is tightly wound on the core, and the mar resistance tester has been found useful for indicating resistance to surface scarring of apparatus housings as they move along an assembly line.

"It may be helpful to distinguish the various characteristics by descriptive names to avoid the confusion which usually arises when hardness is discussed. To this end, it may be desirable to (*a*) eliminate the term "hardness" entirely, (*b*) limit its use to one type of test only, or (*c*) to employ a modifying adjective to distinguish between the various techniques.

"Thus, resistance to penetration or deformation might be classified as hardness if we agree to limit this word to one technique or as penetration hardness if the term is to be used for all methods. Resistance to surface scratching might properly be called mar resistance. If chisel or blade type of scratching tools are employed and the coating is removed from the base, adhesional forces enter the picture and the property measured might be described as scratch-adhesion. Abrasive techniques might be classified under abrasion hardness, or, better still, as simply abrasion resistance."

Part of the second report, submitted by Messrs. D. Smith and M. R. Euverard, both of Interchemical Corporation, is quoted in the following paragraphs:

"It seems feasible to eliminate the use of the term 'film hardness' entirely and to substitute measurements of the pertinent fundamental physical characteristics specified by their appropriate names

"The desirable properties of a film having adequate film hardness have been considered and we have found general agreement that such a film is one which will retain its original surface characteristics throughout its useful life. This would imply that the surface must neither wear nor be deformed if it comes in contact with other objects, if these are the requirements of its usefulness. Any failure other than surface deformation or wear should not be considered to be due to lack of film hardness. In particular, adhesion should not be considered in this respect because this property is concerned only with the ability of the film to stay on the base rather than its ability to retain its original surface characteristics.

"These two mechanisms for alteration of film surface character, abrasion and plastic deformation, are independent of each other.

"The conclusion we have come to is that at least these two properties should be measured and specified independently, and any other properties which seem to be pertinent for a specific application should also be specified separately. A logical course would seem to be the development of satisfactory test methods for the measurement and specification of these two properties.

"We believe that the most important result which the committee might derive from this initial investigation would be the elimination of the use of the term 'film hardness' and the concentration of its efforts on the development of methods for measurement and specification of the fundamental physical properties concerned."

Shortly after the report by Malone and Phair was distributed to the members of the group, Dr. S. C. Horning of E. I. du Pont de Nemours and Co. submitted a letter in which was contained both his comments on the report and his thoughts regarding the physical characteristics of coating materials which should be included under the subject of hardness. Because of the pertinent nature of his comments, parts of his letter are quoted as follows:

"The review of Malone and Phair of the factors determining hardness furnishes a satisfactory basis for a discussion of hardness. As they point out, hardness measurements involve elastic deformation, or plastic deformation, or both. Hardness is therefore some function of the resistance of a material to both types of deformation.

"Stress-strain measurements, the Sward Rocker, and other devices measure resistance to elastic deformation. If errors due to surface roughness and other causes could be eliminated, all methods of determining resistance to elastic deformation should arrange all surfaces in the same order. Also, all methods which measure only plastic deformation should arrange

all surfaces in the same order, which order however may be a different one from that for elastic deformation. Tests involving both types of deformation should give still other orders.

"In view of the above conditions, the suggestion that the term 'hardness' be eliminated is endorsed and it is suggested that the term 'indentation resistance' be used to describe resistance to plastic deformation and the term 'elastic resistance' be used to describe resistance to elastic deformation. Abrasion resistance and scratch-adhesion should not be considered in connection with hardness since they are directly related to properties other than deformation resistance. Mar resistance can be considered as the ability of the surface to resist change because of its hardness characteristics. Brittleness is the resistance of a surface to fracture and, while probably related to hardness, should be considered a separate property.

"Using the above definitions, a hardness test is desired for the purpose of measuring mar resistance. The test must combine indentation resistance and elastic resistance in the proper proportions to predict mar resistance. A study could be made of the correlation of available tests with performance characteristics to determine which test best predicts mar resistance. Another possibility is to establish tests for each factor in hardness under conditions involving the other to a minimum extent and to utilize both for specification purposes until correlation tests are available which indicate the extent to which a change in one factor will permit a change in the other or the extent to which both should be combined in one test.

"The Pfund and Rockwell type testers measure both elastic resistance and indentation resistance since a large part of the applied force is used to overcome elastic resistance. Tests involving needles and indenters of a pointed type, such as the Knoop Indenter, may be influenced less by elastic resistance. For this reason, the various tests involving needles and indenters should be given first consideration in preference to the Pfund or Rockwell testers.

"The objective of the above discussion was to indicate possible lines of attack on the hardness problem. As long as no accurate and sensitive hardness test is available which is known to correlate well with the performance of a finish, it is desirable to utilize tests which involve as few fundamental properties of a finish as possible even if this means two or three tests are required to define the hardness or mar resistance of the finish."

The contents of these two reports and the comments by Dr. Horning were discussed at some length during the Hardness Group meeting which took place in March, 1948, in Washington. The result of this discussion was the definition of three classifications of those physical properties of organic coating films known as elasticity or plasticity. It seemed that the three classifications selected encompassed all the manifestations ordinarily associated by paint technologists with the term "hardness." These classifications were (1) elastic deformation, (2) plastic deformation without rupture, and (3) plastic deformation with rupture.

It was decided that the initial investigations of the Hardness Group would take under consideration various testing methods which measure plastic deformation with rupture, that is, the third classification mentioned above. The reason for giving this classification first consideration was that it was felt that the greatest interest lies in resistance to permanent and obvious change in the coating material considered. It must be pointed out here that the study of this classification implies the study of abrasion resistance techniques. This fact caused considerable discussion in the Subcommittee XVIII meeting in Washington when the report on the group's activities was presented. The thought was expressed by some that abrasion testing was not a proper means of evaluating hardness of organic coatings. The position of the group in this matter was justified, however, on the basis of the subdivisions which have been established for the consideration of the subject of hardness as has been explained above. It was further pointed out that the initial survey and comments at the first group meeting indicated that abrasion testing was associated in the minds of many paint technologists with the rather poorly defined term "hardness." It was agreed that abrasion testing may not at all correlate with use conditions which have in the past been loosely related to hardness but, if this is so, the studies will develop negative results which can be as beneficial as can results which are positive.

Equipment for Hardness Testing

The Gardner-Sward Handbook lists many of the more familiar pieces of equipment employed by paint technologists for the measurement of coating hardness. The various instruments are grouped under general headings related to the physical principles of instrument operation.

A very fine intracompany survey report has been prepared by A. M. White for the American Cyanamid Co. covering the historical background of the interest in hardness measurements and presenting brief discussions of each of several instruments. A revision of this report suitable for publication appeared in the July 26 issue of *Steel*. It is recommended reading for all those interested in the subject of hardness. Although the report places greatest emphasis on the measurement of hardness by indentation methods, its context is considered to be directly applicable to the work of the Hardness Group.

Summary

There seems to be general agreement that two fields of study appear to confront the Hardness Group in attacking this problem of the objective measurement of coating hardness: elastic deformation and plastic deformation of the coating films. It appears also that the subject of plastic deformation must be subdivided into two categories, that is, with and without rupture of the coating film. Techniques must be defined for separating each of these physical characteristics from the other two to the greatest extent possible. Existing equipment must be examined to determine which, if any, will comply with the needs of techniques which must be defined. It may be necessary to suggest the development of new equipment if the existing so-called hardness testers are found unsuitable.

Throughout all of the group's work, the objective will be to find which of the three classifications of measurement, or which combination of the three, will best correlate with the sense of the term "coating hardness" as that term is commonly employed. It must be remembered, however, that the concept of hardness as applied to any material is not very rigidly defined even by those who have made extensive studies of the subject; when the material under consideration is some form of an organic coating, the problem of definition is further complicated by inhomogeneities of the film which occur both in time and in space.

An open mind must be diligently cultivated in this study; cultivated because lack of precise definition has resulted in many different conceptions based upon individual personal experience and prejudice.

H. F. Payne of the American Cyanamid Co., in the opening paragraph of an article titled "Hard to Define" published in *For Instance*, the company organ, has expressed some thoughts which seem apropos. This paragraph is quoted as follows:

" 'Hard as a rock' in common parlance defines an extreme degree of hardness, but rocks range from friable chalk to adamant granite. 'Hard rubber' is softer than soft paste porcelain and 'hard water' defines an entirely different type of hardness. 'Hard to define' implies that hard and difficult are synonomous and 'difficult to scratch it' defines a hard surface. Sufficient hard cider could befuddle things completely."

Testing Surface Waterproofers*

By F. O. Anderegg[1]

SYNOPSIS

Definitions are given for surface waterproofers and methods are described for testing the effectiveness of both the colorless and the cement type in sealing the surface of masonry construction against:

1. Moisture absorption, such as that resulting from a driving rain.
2. Pressure from in back of the wall.
3. Evaporation of water from the surface (such "breathing" or transpiration is believed to be important in maintaining the integrity of the wall).
4. Efflorescent crystal action or freezing.

For exterior surfaces the first, third, and fourth factors are important, but for waterproofing the interior of basement walls the first is not so important. It does what seems to be significant to reduce the size of the capillary openings so as to hold back the given head of water by capillarity, but without too much reduction of the transpiration. The importance of workmanship in applying the material is emphasized, and it is felt that a conscientious and reasonably skillful amateur should be able to waterproof a basement wall, when he follows adequate directions. Such directions are outlined.

A GREAT deal of interest has been shown recently in the problem of waterproofing cellar walls and other masonry structures. Several articles have appeared in nontechnical magazines on this subject. The National Bureau of Standards has published technical papers[2] and even the Federal Trade Commission has given the matter consideration.[3] However, there seems to be lacking a proper analysis of the different waterproofing problems and the factors involved so that it has been difficult to set up reasonable expectations for the performance of waterproofing materials and methods. In addition, there seems also to be a lack of testing methods which will show the effect of the different factors and conditions on the performance thereof.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Fifty-First Annual Meeting, Am. Soc. Testing Mats., Detroit, Mich., June 21-25, 1948

[1] Director, Building Materials Research, John B. Pierce Foundation, Raritan, N. J.

[2] (a) Building Materials and Structures Reports BMS55, "Effects of Wetting and Drying on the Permeability of Masonry Walls."
(b) BMS76, "Effect of Outdoor Exposure on the Water Permeability of Masonry Walls."
(c) BMS82, "Water Permeability of Walls Built of Masonry Units."
(d) BMS94, "Water Permeability and Weathering Resistance of Stucco-Faced, Gunite-Faced and 'Knap Concrete-Unit' Walls."
(e) BMS95, "Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls."
(f) BMS110, "Paints for Exterior Masonry Walls" by Clara Sentel.
(g) Cyrus C. Fishburn, "Prevention of Dampness in Basements," *Journal*, Am. Concrete Inst., Vol. 44, p. 421 (1948).

[3] Federal Trade Commission. "Trade Practice Rules for the Masonry Waterproofing Industry," as Promulgated August 21, 1946.

DEFINITION OF SURFACE WATERPROOFING

Walls of unit masonry construction seem to be prone to leakage whether exposed to driving rains or in contact with moisture laden soil. Treatments applied to the exterior surface of walls above ground level or to the inside of walls below ground level are commonly spoken of as "waterproofing." In probably every case the manufacturer has had experience which has led him to feel that his material is capable of rendering a wall tight against the passage of water and that it will do so under reasonably favorable conditions. Since he has no control over the conditions of application, he cannot guarantee a tight job, and so the Federal Trade Commission has objected to the use of the word "waterproofing" in advertising literature.[3] This word has come to have a definite place, however, in the vocabulary of the building industry and no other seems to fill its place. Therefore, in this discussion "waterproofing" will be used and defined as a material which when applied under proper conditions of workmanship and to suitable masonry will prevent:

1. Ingress of more than 1 lb. of water per square foot in the first hour under a head of $\frac{1}{4}$ in. water, and after one month or more of aging.
2. Egress of visible moisture under a pressure of, say, 4 ft. of water from behind (at any time after the first month).

ANALYSIS OF THE PROBLEM

Among the factors involved in satisfactory, reasonably permanent waterproofing of masonry walls, the following might be listed:

1. The porosity of the wall, involving the size, number, and distribution of the openings. Joints between the units and the mortar are likely to be troublesome.
2. The degree of sealing desired to secure a reasonable balance between ingress of moisture and transpiration.
3. The effect of soluble salts (ions) on the surface treatment, including reduction in breathing, saponification, osmotic pressure, preferential wetting, and efflorescent crystal pressure.

Of the factors listed above, all seem to apply to the waterproofing of exterior walls and all but the rate of water ingress are important to a cellar wall.

TESTING METHODS AND OBSERVATIONS

Consideration of this analysis led to the adoption of certain laboratory tests. Maintaining constant conditions, tests for absorption rate, transpiration rate, resistance to efflorescent salts (first without and then with freezing), and, finally, exposure tests were made. To check the laboratory experiments, treatments have been applied to piers fabricated from cinder blocks and to cellar walls.

The laboratory tests have been run with Hudson common brick. These usually had some large pores and were selected for absorption rates. When placed with the flat side in $\frac{1}{4}$ in. of water, results of 4.5 to 7.5 per cent in 1 min., 9.5 to 14.5 per cent in 10 min., and from 15 to 20 per cent in 24 hr. were obtained, as shown in Fig. 1. The bricks were first dried in the labora-

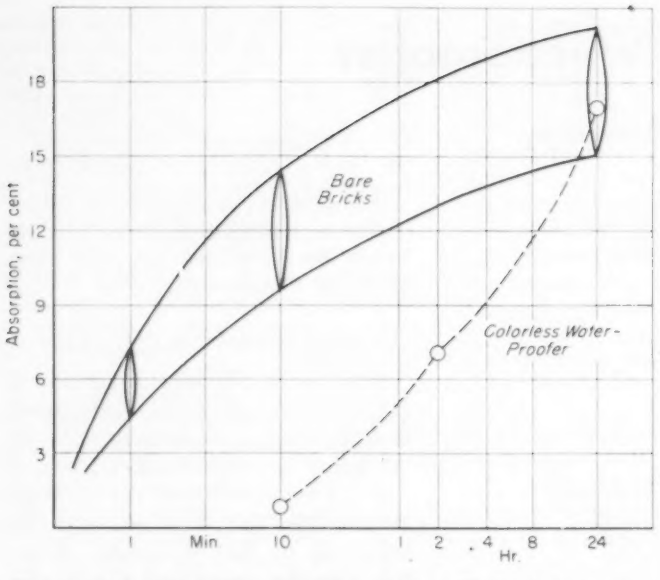


Fig. 1.—Absorption Characteristics of Bare Hudson Common Bricks Used in Testing Waterproofers.

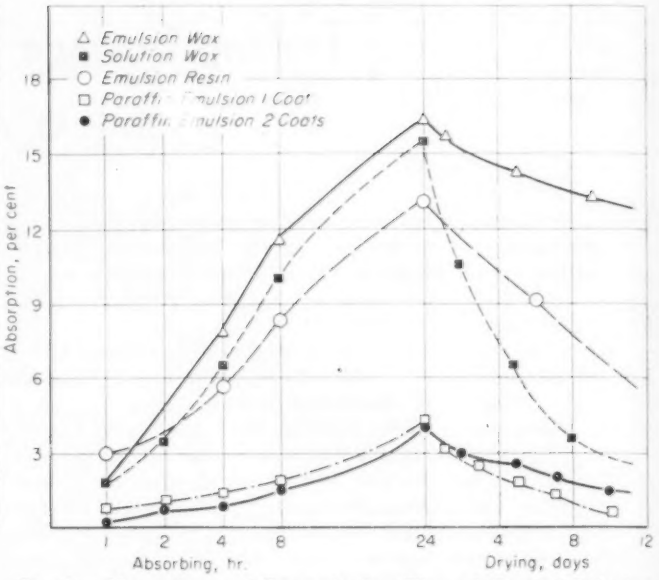


Fig. 2.—Absorption and Transpiration Through Typical Colorless Waterproofings.

tory to a point where the loss in 24 hr. was less than 10 g. With colorless waterproofing treatments or where organic vehicles containing pigments were used, two coats were usually applied with an interval of 24 hr. between applications. The application was made to the flat side and to the four edges of the dry bricks. Sometimes the absorption and breathing tests were run on a single coat as well as on a two-coat application.

When cement-type paints were to be applied, the bricks were immersed in a pail of water until the bubbling of air substantially decreased. After application according to the manufacturer's directions the coatings were cured under wet rags for 24 hr. after the cement had set. A second coat was then applied, cured moist for 24 hr., and then sprayed daily until one week old. The bricks were then allowed to dry in the laboratory air, which in these experiments was at 70 ± 5 F. and 20 to 30 per cent relative humidity. By noting the weight of original dry bricks and again after treating and drying, an estimate of coverage could readily be obtained.

The weighed bricks were placed in a pan with the flat, treated side down in water maintained at a level of $\frac{1}{4}$ in. This corresponds roughly to the pressure exerted by a 20-mph. breeze. After one hour they were removed, wiped free of superficial moisture, and weighed; the same was also done after approximately 2 hr., 4 hr., and 24 hr. Usually ten bricks were averaged for each datum.

The bricks were then placed on a rubber sheet with the treated flat side upward and were weighed from time to time to determine the rate of drying or of transpiration through the waterproofing coating.

Many of the bricks were given a second contact with water, and it was noted that the rate of water absorption was lower in the case of the bricks treated with cement waterproofers. During the first contact with water and subsequent drying, lime and other soluble material had apparently been brought toward the surface and there deposited to reduce the superficial pore area.

Typical results are given with several colorless waterproofing compounds in Fig. 2. The finer pores seem to be pretty well closed, as judged by the reduction in rate of transpiration, but the coarser pores are apparently incompletely sealed. This seems logical when it is remembered that the organic solvent of the solution, or the water part of the emulsion, occupies the bulk of the material applied.

The shape of the absorption rate curves is interesting. In some cases it is nearly straight when the logarithm of the time is plotted against percentage gain. Again the curve is concave upward, indicating an initially slowed down period of establishment of capillary contact with the interior of the brick. These results seem to indicate that an exterior wall treated with a colorless waterproofing tends to become a moisture trap, depending upon the ratio of wet to dry weather.

The rate of absorption through cement-type waterproofing, as plotted in Figs. 3 and 4, varies greatly. Certain of the proprietary treatments have exerted a marked effect in reducing this absorption. Some of these contain stearate. At the same time the rate of drying indicates the presence of a fairly large total pore area. The ability of this type of waterproofing to hold back considerable heads of water, as described below, indicates pore diameters of a few microns. The evaporation rates, then, must depend on the presence of a very large number of pores. The granular structure of the cement, and of the cement gel resulting therefrom, supports this assumption.

After completing the absorption and drying experiments, the bricks are placed for two weeks with the *untreated* side in contact with 10 per cent sodium sulfate solution held to a depth of $\frac{1}{4}$ in.

The pattern of salt deposit developed on the upper surface seemed to give a pretty good picture of the location of the larger, poorly sealed pores. The contrast between the

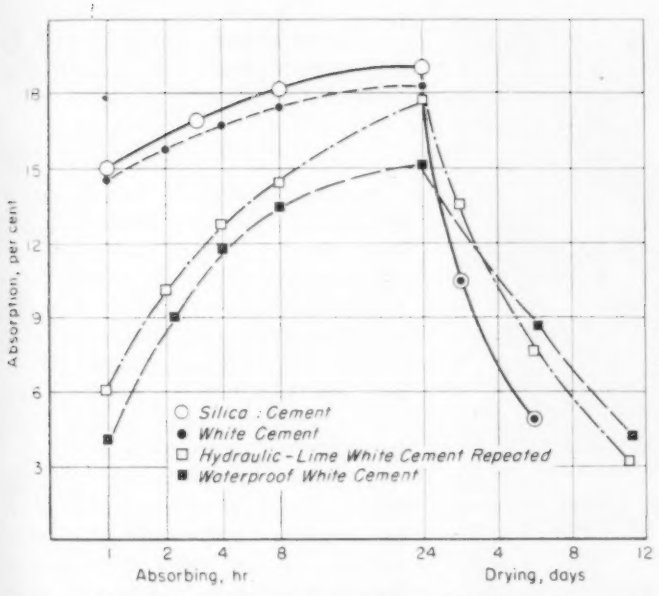


Fig. 3.—Absorption and Transpiration Through Different Cement Coatings.

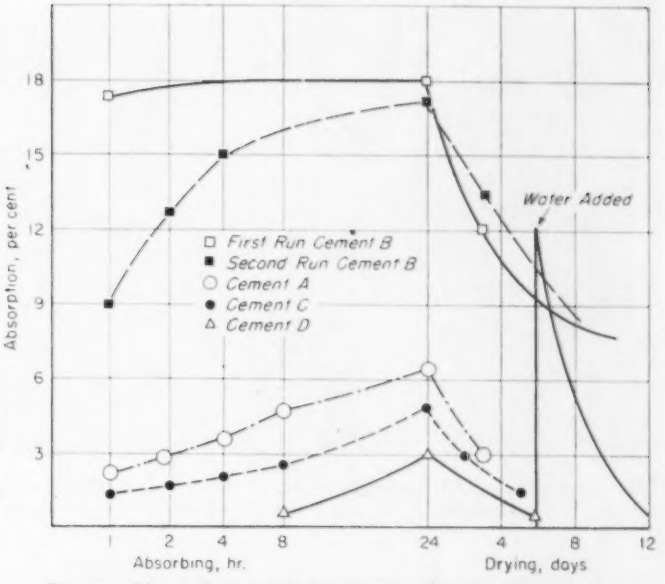


Fig. 4.—Absorption and Transpiration Through Proprietary, Cement-Base Waterproofings.

white salts and the red surface of the brick coated with colorless waterproofing facilitated observation of this pattern better than on the white background where the other type of waterproofing was used. But all of the treatments tried seemed to have difficulty in sealing pores greater than ½ mm. (0.02 in.). The reasons for such imperfect sealing lie in the surface tension where water was the suspending or dispersing medium, or in the large volume of volatile solvent where the colorless treatment is in solution. By very thorough scrubbing it is possible to work the material down into many of the smaller pores or into the coarser shallower pores. However, it is advisable to inspect the whole surface carefully, especially along the joints between mortar and units, and rub into all openings greater than a pinhead a little 1:2 mortar made with fine sand.

When white portland cement alone was applied to the wetted bricks and properly cured, the surface appearance was as if they had been glazed. Such glazed surfaces tended to resist the exudation of the salt in the efflorescent test. Under certain conditions, however, the crust formed by this glazed cement was pushed off bodily by efflorescent crystal pressure. Figures 5 and 6 show these phenomena. Similar phenomena may be seen in old masonry walls which have been whitewashed or painted with cement or casein paints or have acquired a crust in other ways.

Following this test, the bricks, still containing considerable amounts of salt solution, were placed in a quick-freeze compartment and their temperatures were lowered to −10 F. in a period of approximately five hours. The combined action of ice pressure and efflorescent crystal pressure have succeeded in the pushing off of still more of the surface treatment.

The bricks, after being frozen and thawed, were exposed on the laboratory roof over the winter. The effect on typical coatings is shown in Fig. 7. In several places waterproofing coatings of the cement type have been pushed off bodily, especially where the coating was rather thick. The thinner applications seemed to resist detachment much better.

Considerable areas, particularly in the case of many of the colorless materials, were laid bare. On running absorptions on these bricks, the rate approached that of the untreated brick in proportion to the area from which the coating had become detached.

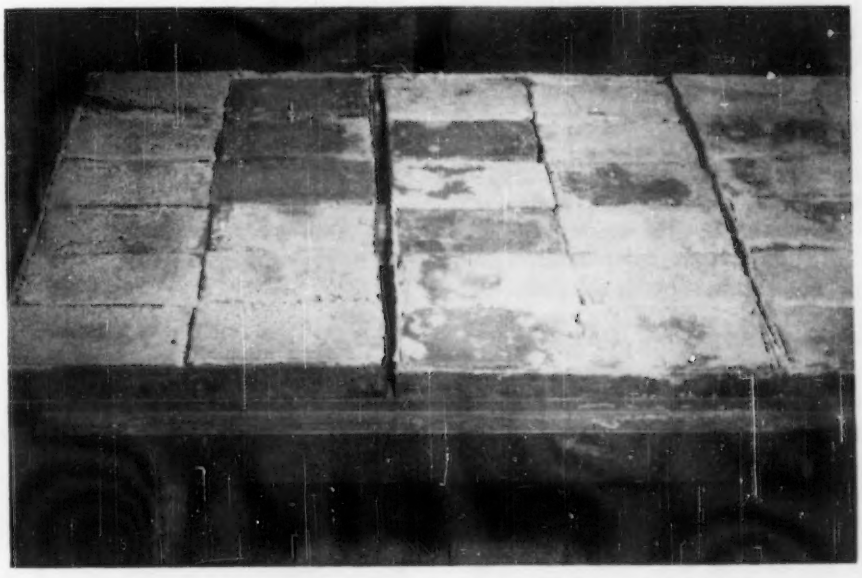


Fig. 5.—Efflorescent Pattern Appearing on Waterproofed Bricks.

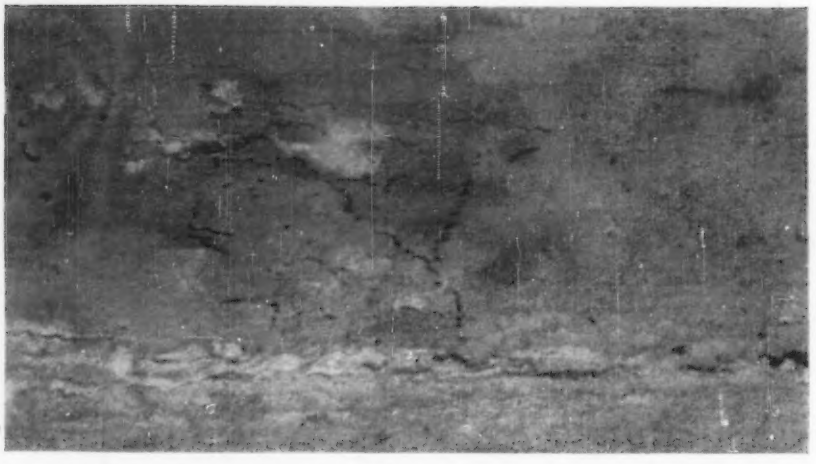


Fig. 6.—Surface Waterproofing Crust Pushed Off by Efflorescent Crystal Pressure. The Apparently Dotted Lines Are the Edges of the Crust So Lifted.

Applications to Masonry Piers

The laboratory findings were checked by applying certain of these waterproofings to piers made from cinder blocks as shown in Fig. 8. This is William S. Elliott's proposal.[4] The behavior of these coatings followed closely what had been noted in the laboratory. The area of the moisture appearing on the pier surfaces seemed to vary with the rate of absorption by the bricks coated with the given material.

The application on the central pier was a colorless material and was used because the producer had recommended it for painting on the inside of basement walls. A very interesting pattern of leakage developed on filling with water, as shown in Fig. 9. The water-repellent nature of the coating caused the water leaking through to appear as beads. It will be noted that the bulk of the leakage is along the joint between the top of the mortar and the bottom of the unit. This is a very graphic demonstration of the most common path of leakage in masonry. Had there been vertical joints, a similar pattern would probably have also developed.

Surface Tension and Head of Water:

By applying the usual surface tension formula, it is readily possible to calculate the diameter of a pore which will hold back a given head of water. Transforming it into convenient units, this equation may be written:

$$hd = 94$$

where h is the head of water in feet and d is the pore diameter in microns (0.001 mm.). This means that if the diameters of the pores in the hydrated cement surface treatment are reduced to or below 9 μ, liquid water will not ooze out under a head of 10 ft. Dunagan[5] reports a "stored up" pressure of water within concrete of 15 psi. This corresponds to a head of water 34.6 ft. high and indicates a mean pore diameter of about 2.7μ.

However, evaporation of moisture from the surface of these pores is not prevented. As a matter of fact, capillarity will keep these pores pretty well filled at the surface as long as moisture remains in the units in appreciable quantities. This means that evaporation will proceed as shown in Figs. 3 and 4, at a pretty steady rate until the units are nearly dry.

Application to Walls

An additional check was obtained by successfully waterproofing a cellar cinder block wall and a similar wall around a water meter manhole. This manhole, originally full of water, was pumped out, and was finally, after much hard work, rendered watertight. Leakage occurred through part of the floor, through the joint between the concrete floor and the blocks, through the joints between the mortar and the blocks, and through many openings in the block. The whole floor and wall were in direct contact with a heavy clay soil. After cleaning and wetting, part of the wall was treated directly with a cement-base waterproofing, applied with a fender brush and with vigorous scrubbing. However, this was not always sufficient to seal the larger pores. These were dug out, pointed up with a mortar made of fine sand (approximately 1:2 mix), and finally painted over. The remainder of the wall was gone over after cleaning and all holes readily perceptible were pointed up with this mortar.

The joint between the wall and the floor was dug out laboriously with a cold chisel leaving a dovetail groove, which was filled with stiff mortar. Water continuing to come in at certain places afforded opportunity of testing out several different plugging cements. It took some practice to get the timing just right in applying these. The

[4] William S. Elliott, Personal Communication.

[5] W. M. Dunagan, "Methods of Measuring the Passage of Water Through Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 39, p. 877 (1939).

Fig. 7.—Waterproofed Bricks Have Been Exposed on the Roof Over Winter, Following the Laboratory Tests. Most of Them Have Suffered Severely.

plug, formed in the hands, is worked until it begins to stiffen somewhat, when it must be pushed in and held for at least 60 sec. until set. Several plugging cements are available for this purpose. Five were tested and found to be capable of sealing off water pressure, if properly handled.

In applying cement-type waterproofing to basement walls, the face must be clean, bare masonry, which should be about three-fourths saturated with water. Very old cellar walls, as shown in Fig. 10, are apt to contain appreciable amounts of efflorescent salts, the presence of which is very apt to spoil any benefits to be expected. Such joints should be dug out to a depth of 1 to 1½ in. and the bottom ½ in. should first be caulked with a mortar containing asphalt emulsion using about 5 per cent of the emulsion based on the aggregate. Finally the joints should be well wetted and pointed with 1:1:4 slightly stiff mortar or its equivalent. This applies to walls of rather dense units. If porous bricks had been used and this treatment is carried out, the bricks themselves will disintegrate by efflorescent crystal action, unless the lime content of the mortar is increased. The current saying in regard to waterproofing applications of the industry should be borne in mind—"ninety per cent of the effectiveness of the waterproofing lies in the workmanship." Plenty of conscientious, hard work is necessary if a tight cellar wall is to be secured.

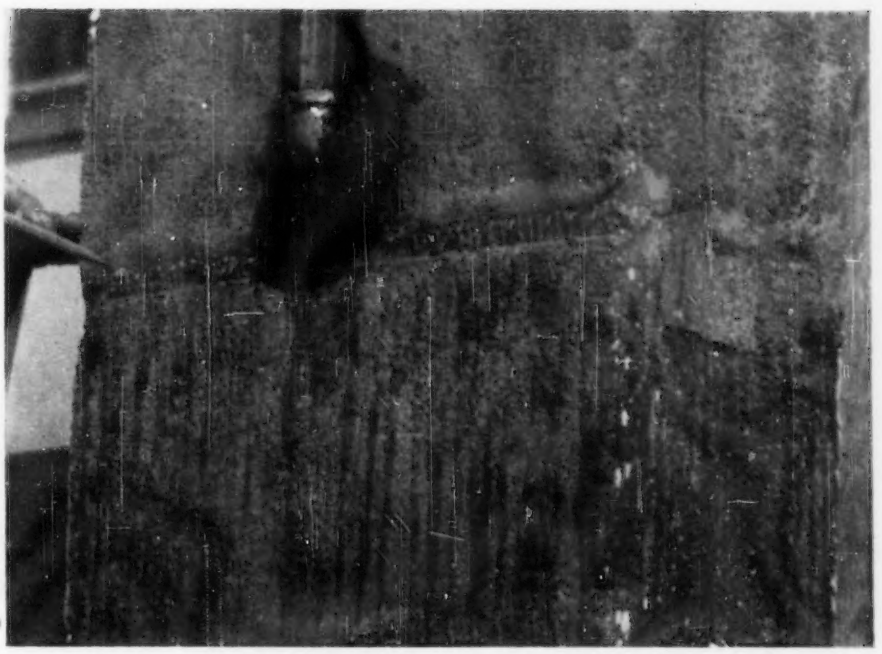


Fig. 9.—One Pier, Coated with a Proprietary Colorless Waterproofing Treatment, Developed a Row of Water Beads when Filled with Water.

Conclusions

The methods of applying both cement type and colorless waterproofing coatings to bricks of suitable absorption properties followed by observing the rate of water absorption through the coatings and their rate of transpiration, seem to correlate well with their behavior on test piers and on walls in the field.

The exposure to sodium sulfate solution, followed by freezing, seems to produce an effect similar to that frequently observed on older masonry walls. When the same bricks are then exposed on the roof over winter the results are estimated to be similar to what would be obtained in ten or more years of rather severe exposure.

Difficulty has been experienced with all treatments in sealing pores of ½ mm. or larger diameter. Two coats were more effective than one and should, of course, be applied without fail. The advisability of sealing all visible pores first with 1:2 pointing mortar is emphasized.

The cement type of waterproofers leaves, apparently, numerous pores of a few microns in diameter capable of holding back a head of water of several feet. These treatments reduce the rate of moisture absorption but do not prevent it. They also permit transpiration of the wall, which is believed to be very important for maintaining its integrity. With wetting and drying, the pore openings in the cement waterproofings become partly filled.

Provided the initial pores are not too large, certain of the colorless waterproofers seem to be capable of sealing them effectively to prevent ingress of moisture as well as transpiration. However, failure to seal the larger pores may permit entrance of rain water, while the adequate sealing of the finer pores may seriously interfere with the "breathing." If complete sealing is desired, the wall should be care-

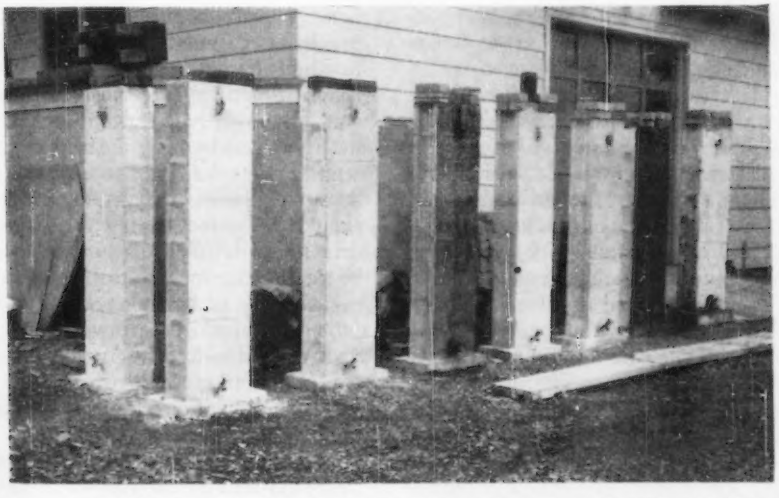


Fig. 8.—Piers Made of Cinder Blocks Have Been Coated and Tested with Water.

fully pointed, cement type should be applied, and finally a colorless treatment should seal all pores.

The continued, effective bonding of colorless treatments to masonry surfaces is usually reduced by oxidation, preferential wetting, efflorescent crystal pressure, osmotic pressure, or frost action. Although permanently flexible, nonoxidizing films might be able to resist these agencies, the exposure is obviously very severe.

Plugging cements are available with which the flow of water can be stopped. With conscientious and intelligent effort, one should be able to seal a basement wall against water ingress.

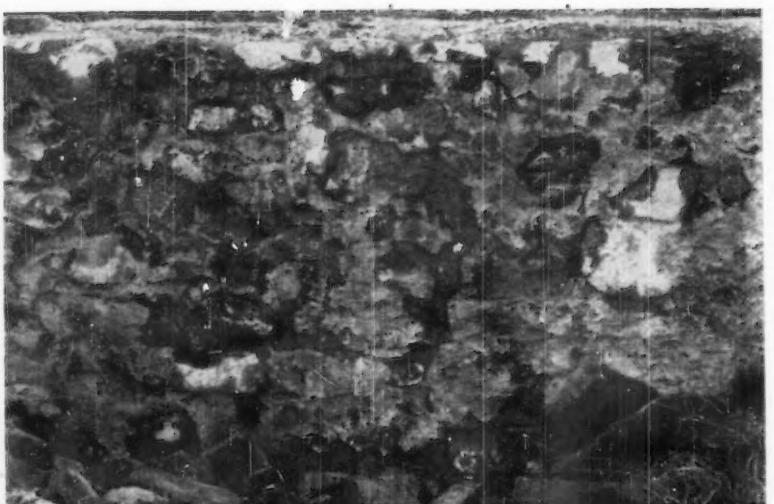


Fig. 10.—An Old Foundation Wall Built of Field Stones Laid in Soft Mortar and Later Coated with Whitewash. Efflorescent Crystal Pressure Has Pushed Off Much of the Crust of Whitewash.

DISCUSSION

MR. D. E. PARSONS.[1]—Mr. Anderegg referred to a publication of the National Bureau of Standards in which there was a statement to the effect that 2 per cent of stearate was needed for optimum effectiveness. That was an unfortunate error. The author of the paper actually used compounds that contained about 10 per cent of stearate, and the 2 per cent figure applied to the compounds rather than to the stearate.

MR. F. O. ANDEREGG (*author*).—That made it about 2 tenths per cent on the cement.

MR. PARSONS—Yes. I believe that agrees closely with your figure.

MR. WILLIAM S. ELLIOTT[2] (*presented in written form*).—Mr. Anderegg's presentation of the problem of surface waterproofing of leaky masonry walls is an excellent beginning to a discussion which cannot be closed in the immediate future. There are too many open questions and great ramifications in the use of surface waterproofers which do not occur in an initial surveillance of the problem.

I have always felt that the place to stop water from leaking into a building is at the outer masonry face, and that can be done adequately by either a cementitious or transparent type waterproofing applied by scrubbing the material into the open pores by brush application. Stopping water ingress by that means is thoroughly practical and feasible. Good workmanship is an essential element in this treatment but good in this case does not necessarily mean costly. It is a laborer's job to be done under intelligent supervision.

A water barrier is, of course, not a vapor barrier, and it is necessary that the wall be able to breathe to permit transpiration of any entrapped moisture to the outside atmosphere. Conditions where continued rain might permit a large percentage of the potential absorption of masonry units to be satisfied are very unusual in the United States. Normally there is ample time for transpiration of any entrapped moisture between rain storms. Weep areas at the bottom side of any wall can easily be provided to prevent moisture traps. Hard driving rains usually occur for very short periods and the best of the surface treatments are adequate assurance against penetration of such moisture.

Surface treatments on the inside of a wall to prevent seepage of ground water can be demonstrated as effective under heads of 8 ft., the maximum encountered in normal home construction where this type material has its greatest usage. Iron filings in cement coatings have been used for many years as a satisfactory protection against seepage of ground water. Proprietary cementitious paints do the same work in a simpler fashion eliminating the need of skilled mechanics as applicators.

Building Materials and Structures Report BMS-95 of the National Bureau of Standards indicates that several cement paints of the cheap variety do a good job of waterproofing masonry walls. However, the Bureau will not release information as to which of many are the good ones. After you have applied such materials it is difficult to correct for a poor material so that proper waterproofing can be applied. Material cost is a small part of the total cost and value of the finished waterproofed wall.

The A.S.T.M. has a challenge in this field to develop a standard method of test for performance of surface waterproofing treatments. The tests should be simple but effective and in such terms that a practicing architect or engineer can judge relative merits of such products without getting into the deeper realm of physics. If the material is to be used against a hydrostatic head it should be tested that way. If wind-driven rain is the source of moisture to be guarded against, the test should show performance under such conditions.

The test procedure developed by me and referred to by Mr. Anderegg served one specific purpose, it proved that thin surface applications applied to highly porous masonry on the inside of a wall would hold back a hydrostatic head of water existent on the outside. An 8-ft. head was adopted, since that meets the

[1] Chief, Building Technology Div., National Bureau of Standards, Washington, D. C.
[2] Materials Engineer, W. S. Elliott & Co., New York, N. Y.

most severe condition encountered in actual work. It is, undoubtedly, a better indication of the usefulness of such products than tests where the procedure for testing simulates wind-driven rains.

Currently used surface coatings for the exterior face of masonry walls serve many needs in the construction industry by preventing penetration of water and preserving the appearance of the wall. Disintergration, efflorescence, etc., are reduced to a minimum by such coatings. Tests suitable for the rating of such products are needed.

Mr. Anderegg lays considerable stress on the pore size which is important to develop capillary restraint to the passage of water. However, most building materials used in exposed locations have relatively small pores. Sometimes the use of plugging cements is objectionable from an aesthetic point of view or because of the skilled labor involved. Good workmanship can fill the deep caverns and waterproof the pores within the caverns, this providing an effective water barrier.

The scientific admission of Mr. Anderegg that "With conscientious and intelligent effort, one should be able to seal a basement wall against water ingress," opens the door to a new waterproofing industry. It provides another and much cheaper method of keeping masonry buildings dry. His work is commendable.

MR. C. C. FISHBURN[3] (*presented in written form*).—Mr. Anderegg's paper in part discusses the passage of moisture through coatings of surface waterproofings applied to Hudson common brick. The passage of water by capillarity into masonry walls is of much less importance than is the leakage of wind-driven rain through openings larger than pore spaces. The leakage of water in quantity sufficient to produce a flow on the inner faces of walls occurs principally at the joints in the masonry. A surface waterproofing treatment should prevent such leakage and a logical test of the treatment or material should therefore be made on coatings applied to an assembly of masonry units such as a wall or wallette. The surface of the test wall should contain a fair proportion of joints, especially vertical or head joints.

The author also discusses tests of piers built of hollow concrete masonry units. The core spaces in the units, interior of the piers, are filled with water and the outer faces of the units are treated with a surface waterproofing. Since there are no vertical joints in the piers, the piers do not accurately represent or simulate the conditions commonly found in concrete masonry walls. The piers are much less permeable than are the walls. Furthermore, if the capacity of the air in a basement to carry moisture is greatly limited by meteorological conditions, the entrance of moisture into a basement by evaporation from a surface waterproofing may be undesirable even if there were no leakage.

MR. W. C. VOSS.[4]—I should like to endorse Mr. Fishburn's statement. I should like also to ask Mr. Anderegg whether he made any tests which would give curves covering an assemblage of units.

I should like to call attention to another factor which is important in considering weathertight masonry walls. This is the fact that most masonry walls are in continual vibration. Furthermore, with slabs bearing directly on the wall the negative moment causes exterior tensions. These will vitiate entirely any of the theory that scrubbing in surface materials which become rigid will stop cracks.

While it is a good idea to test a brick for the flow of vapor or moisture through a colorless waterproofing, it is equally important that an assemblage test be made using the same waterproofing to span the joints.

We conducted a five-year series of tests, some twelve years ago, on colorless waterproofings. We made single brick and three brick test specimens. There was not a single one of the colorless waterproofings of the 36 tested that protected the brick assemblage, exposed alternately on the roof and in the laboratory through the five years.

The problem of breathing of a wall is an important element of this entire problem. I have inspected a great many parapets where an asphalt smear had been applied on the back of the brickwork to keep the water out, and I was amazed when I inspected some parapets in which water-struck brick were so treated with hot applied asphalt to find that they were leaking worse than those not so treated. When we took some of the ruptured brick off in the winter, they were covered with crystals of ice, at the break. A wall has to breathe and if you put colorless waterproofing on the outside which is not a perfect seal and you seal the wall on the inside, in such a wall, as Mr. Anderegg says, "a lot of dirty things" can happen.

Sealing water into the wall and allowing freezing pressures to grow up in the interior starts the initial disintegration of a good brick or of the wall itself.

We must keep as much water out of the wall not only after it is built but while it is being built. If we do this, and get only the water that is in the mortar into the wall and do a good job on the surface and insist upon good workmanship, we will not need either rigid or so-called flexible colorless waterproofings.

MR. MAURICE COBURN[5].—We keep hearing about iron filings. It is ground cast iron, not filings, a valuable material when used with intelligence.

My information concerning colorless waterproofings is that they are a temporary material. They coat the cell walls and make them water repellent, but in a few years that value is all gone.

I have seen many backs of parapets coated with an impervious material, as Mr. Voss has said, where the wall was badly damaged. The wall must be able to dry out or "breathe." That is one advantage of the iron waterproofing.

Most leaky brick walls can be cured only by proper repointing. There was tremendous damage done by the use of a stiff mortar with cement alone. Before long bond was lost and the wall leaked, and repair was necessary.

MR. ANDEREGG (*author's closure*).—I agree with all the comments made. I appreciate the comments on the wall. I built 300-odd panels, and all but six leaked through the joints, about as much through the vertical joints as through the horizontal joint.

In the present tests I was careful to choose bricks which had some rather large pores. I used at least ten bricks in each experiment. Mr. Voss's comments about parapet walls are all too true. I have seen parapet walls taken down at the end of the driest summer on record, which were sopping wet. Water had entered through crevices and probably also as vapor from the interior. The dense surface permitted negligible evaporation so that these parapets were actually moisture traps.

The application of bituminous coatings to prevent ingress of water, or water vapor, has all too often failed to accomplish the results desired. According to my tests, checked by considerable field experience, a bituminous coating must be applied as a mastic with a trowel skillfully to produce an impervious surface. Such coatings have cold flow and do not resist water pressure from within the wall.

---

[3] Materials Engineer, National Bureau of Standards, Washington, D. C.

[4] Head, Dept. of Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass.

[5] Represents American Railway Engineering Assn., Indianapolis, Ind.

[Index to Advertisers appears on page 95]

PROFESSIONAL CARDS

On this page are announcements by leading organizations and individuals of their services.

SAM TOUR & CO., INC.

Mechanical, Chemical, Metallurgical Engineers — Consultants

Research & Development Laboratories

44 Trinity Place New York 6, N. Y.

THE JAMES H. HERRON COMPANY

Engineers, Chemists, Metallurgists

Consulting, Inspecting, Testing

Physical, Chemical, Metallographical & X-Ray Laboratories

1360–1364 West Third St., Cleveland, Ohio

PATZIG TESTING LABORATORIES

ENGINEERING INSPECTION

TESTS · ANALYSES · RESEARCH

—OF—

EQUIPMENT · APPLIANCES

MATERIALS & PRODUCTS

Ingersoll Ave. & 23rd St. Des Moines, Iowa

SOUTHWESTERN LABORATORIES

Consulting, Analytical Chemists and Testing Engineers

Inspections, Testing and Chemical Work

Fort Worth, Dallas, Houston, and Corpus Christi, Texas

W. B. COLEMAN & CO.

Metallurgists-Chemists-Engineers

Spectroscopic Analysis

Chemical and Physical Testing

Metallurgical Investigations

Boiler Water Conditioning

Consultation Service

9th & Rising Sun Ave., Philadelphia 40, Pa.

United States Testing Company, Inc.

Hoboken, N. J.

Testing • Inspection • Consulting

Product Development & Research

Boston • Chicago • Los Angeles • New York

Philadelphia • Woonsocket

THE WAYNE LABORATORIES

Chemists Bacteriologists Consultants

Technical Service Research for Industry

Metallurgy, Paints, Bitumens, Oils, Ceramics, Cement and Concrete. Inorganic and General

Physical Testing, Technical Photography, Microscopy, Waterworks, Sewage, Waste Disposal

17 E. Main St. Waynesboro, Pa.

COAL ANALYSIS PREPARATION

POWER PLANT ENGINEERING

COMMERCIAL TESTING & ENGINEERING CO.

307 N. Michigan Chicago 1, Illinois

Charleston, W. Va. Toledo, O. Cleveland, O.

Terre Haute, Ind. Norfolk, Va. Baltimore, Md.

Philadelphia, Pa. Rochester N. Y.

Cincinnati Testing & Research Laboratories

Industrial Research and Development

Specializing in Plastics

Physical, Electrical, and Chemical Testing

308 W. Fourth St. Cincinnati 2, Ohio

ST. JOHN X-RAY LABORATORY

CALIFON, N. J.

Established 1925

PHONE: CALIFON 49

NATIONAL SPECTROGRAPHIC LABORATORIES, INC.

6300 Euclid Avenue Cleveland 3, Ohio

Specializing in Spectroscopy

Qualitative and Quantitative Analysis

CHEMISTS ENGINEERS

Public Service Testing Laboratories, Inc.

Chemical, Physical, Biological

Tests and Analyses

Certified Marine Chemists— — Corrosion Experts

Samplers — — — Research Studies

381 Fourth Avenue New York 16, N. Y.

FOSTER D. SNELL, INC.

Chemists — Engineers

Our chemical, engineering, bacteriological and medical staff with completely equipped laboratories are prepared to render you *Every Form of Chemical Service.*

Write today for a copy of Booklet #8

The Chemical Consultant and Your Business

29 W. 15th Street New York 11, N. Y.

ELECTRICAL TESTING LABORATORIES, INC

Specializing in technical services to those intent upon GOOD QUALITY

2 East End Avenue *at* 79th St. New York 21 N. Y.

PENNIMAN & BROWNE, INC.

Established 1896

CHEMICAL ENGINEERS

• ANALYSTS •

Laboratory and Field Service

Research Testing Inspection Sampling

341 ST. PAUL PLACE • BALTIMORE 2, MD.

ROBERT W. HUNT COMPANY ENGINEERS

Inspection, Tests, Consultation, Research

CHEMICAL, PHYSICAL, X-RAY, METALLURGICAL, CEMENT and CONCRETE LABORATORIES.

175 W. Jackson Blvd., CHICAGO, *And All Large Cities*

Metallurgists Chemists

NEW YORK TESTING LABORATORIES, INC.

80 WASHINGTON STREET, NEW YORK 6, N. Y.

Consulting and Research Engineers

Mechanical, Physical and Electrical Tests, Inspections on all materials.

LUCIUS PITKIN, INC.

ESTABLISHED 1885

Metallurgical Chemists & Consultants

Analysis—Sampling—Assaying

Spectrography—Metallography

Corrosion Studies—Research

PITKIN BLDG., 47 FULTON ST., N. Y. 7, N. Y.

The Oldest Commercial Laboratory in America

BOOTH, GARRETT & BLAIR

Established 1836

Analytical and Consulting Chemists

Samplers and Weighers

228 South Ninth Street Philadelphia 7, Pa.

South Florida Test Service

Testing • Research • Engineers

Development and testing of materials and products. Predetermination of durability and permanency by actual exposure or service tests.

4201 N. W. 7th Street, Miami 34, Fla. Established 1931

A. W. WILLIAMS INSPECTION COMPANY

Timber and Timber Treatment Inspections

Also

Complete Chemical and Physical Testing Laboratories

EXECUTIVE OFFICE: Mobile, Alabama

BRANCH OFFICES: New York, N. Y., St. Louis, Mo., Eugene, Ore.

LEDOUX & COMPANY, INC.

Chemists, Assayers, Engineers

Samplers and Weighers

155 SIXTH AVE.

NEW YORK, 13, N. Y.

Shilstone Testing Laboratory

INSPECTING AND CONSULTING CHEMISTS & ENGINEERS

CARGO SURVEYORS

New Orleans, La. Houston, Tex.

Corpus Christi, Tex.

Inspection at all Leading Industrial Centers